EDUCATION
TECHNOLOGY
at the CROSSROADS

Choosing
a new
direction

Warren E. Hathaway

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Education and Technology at the Crossroads

Choosing a New Direction

Warren E. Hathaway
March 1989

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Preface

American schools are in trouble. In fact, the problems of schooling are of such crippling proportions that many schools may not survive.

(Goodlad, 1984: 1)

School districts and schools that don't make the grade should be declared bankrupt, taken over by the state and reorganized.

(National Governors' Association, 1986: 3)

The public perception is that the changes that have been made over the last two decades or so have resulted in a deterioration of quality, particularly with regard to language and mathematics skills.

(Wilkinson, 1986: 540)

American public education is beset by systematic structural problems that neither of its two most promising reform movements alone can solve. The current 'excellence movement' and the push for vouchers are both well-intentioned and far-reaching, but neither effort will fully achieve its objectives unless we also undertake sweeping changes in the educational delivery system itself.

(Finn, 1987: 2-5)

Recent studies provide a grim picture of U.S. achievement even in the elementary grades.... U.S. students fall further behind the Japanese and Taiwanese at each grade level; and, by fifth grade, the worst Asian classes... exceeded the best American class.... Recent achievement comparisons in high school mathematics also showed that American high school students score on average at the first or second percentile of Japanese norms.... Thus, by measurable standards, U.S. educational productivity has not kept up even with that of U.S. smokestack industries such as steel, automobiles, and consumer electronics that are no longer world-class competitors in quality and costs.

(Fraser, Walberg, Welch & Hattie, 1987: 148-149)

In an era when the prosperity of our society and the well-being of individuals will increasingly depend on having a highly-educated population, approximately one out of every three young people in Ontario drops out of high school before having completed Grade 12.

Uncounted others are 'psychological dropouts' who drift aimlessly through the system eking out the minimum requirements for a diploma, then enter adult life still deficient in the knowledge, skills and attitudes needed to function effectively in today's complex and demanding society.

(Radwanski, 1987: 7)

Education is in trouble in North America.

Clearly (and on the basis of recent research conducted on both sides of the border) there is a problem -- a universal problem -- expectations for educational achievement are not being met. The critical question is, How can education be improved?

What follows is an attempt to provide an answer to that question and that answer is to design, develop, install, and implement a new and technologically-enhanced learning system -- a learning system that could glean the benefits of the higher student achievement levels found to be associated with individualized instruction. Towards that end, specifications and a preliminary design for a technologically-enhanced learning system are proposed, both based on presently available resources.

Sometimes we obtain the clearest notions of the way things could be when we take the time to stand back and assess where we are and where we have come from before deciding what it is that we want to do or where we want to go. The traveller does this by referring to charts and maps.

In education, suitable charts and maps are often difficult to find and if some are found they often lack much of the desired detail. Nevertheless, the educational traveller, or educational pilgrim, cannot stand still. The journey must continue.

For the educational traveller who decides to press on, this book provides a mapping of some of the terrain already covered, an inventory of the resources available to support the continuing journey, some guesses about what lies ahead, and a proposal for a new learning system that might be of use during the continuing journey into the future.

Technology changes the way people do their work.

Looking back in history one finds evidence to support the conclusion that new technologies almost always change the way people do their work -- it provides them with new and better tools. Evidence also suggests that technology has not yet impacted education to an extent where it has changed the way educators do their work. Rather technology in education has amounted to little more than additions of capital and equipment to an already labor-intensive system, but without significant increases to productivity. This is not too surprising when one remembers that because technology changes how people work it also changes how a nation's wealth will be distributed through wages. For this reason all occupational sectors (at least initially) resist technological advances into their workspaces. Nevertheless, technology is a force that must be dealt with in education and because of the rapidity with which the technological force is growing, it must be dealt with soon. One of the problems is that of devising ways of using technology which are both effective and efficient and which also strengthens the professional role of teachers. In this regard, and drawing on the evidence gleaned from projects mounted during the accountability era of the 1960s and early 1970s, Harry Wolcott advocates caution when attempting to find, "... ways for educators to demonstrate their accomplishments, both within their ranks and to the public" (1977: 241). The lesson which may be learned is that new educational approaches must be designed to help teachers do those things they regard as important.

Henchey (1986c) describes three scenarios or images of education in the future. The Superindustrial Scenario, is an image of education driven by technology and industrial models of competition and efficiency. The second image is an Authoritarian Scenario wherein accountability and economic/political instabilities propel educational change. The third scenario is the Ecological Scenario, a scenario in which social pressures are treated as the dominant forces for change.

If one were to watch the splash of a stone tossed into a pond followed by a series of ripples lapping on the shore, one would have observed a good analogy of the forces of change that are now upon us. In a sense, one might rightly consider the stone to be technology, the initial splash to be the economic/political instabilities introduced by technology, and the ripples lapping on the shore to be the social repercussions. In education, it seems that most change is in response to these relatively minor social pressures while the much stronger pressure of technology and its attendant economic/political overtones are all but ignored.

In an attempt to overcome some of today's perceived educational deficiencies, and based on an inventory of available resources, I have used Henchey's work as the basis for a Composite Scenario of education and then used that scenario to support an image or vision of the way education could or should be in the future. Some of these available resources include both technology (computers and telecommunications) and selected industrial models (flow-charting, networking, operations research, reliability and quality control, value analysis, and planning and evaluation systems). The resulting vision is one of a highly productive educational delivery system that enables students, in schools or elsewhere, to pursue their own individualized and customized educational pilgrimages through use of a technologically-enhanced learning system that automatically generates Individualized Educational Plans, employs carefully designed and delivered learning resources, and provides an integrated management system.

This image or vision of education as it could be is firmly rooted in the belief that when fully integrated into a working environment, technology changes the way the people in that environment do their work. When fully integrated into the educational environment, it is reasonable to expect that technology will significantly change many facets of conventional educational practice.

Technology will change:
- *teachers' work*
- *treatment of students*
- *certification of achievement*
- *facility designs.*

First, technology may modify what teachers do. Most significant may be a shift in the teachers' role from dispensers of knowledge to students to one of helping students acquire knowledge from a variety of sources. Second, technology may change the way students are treated. Rather than requiring all students to acquire the same sets of skills in the same time frame, students may become the benefactors of more individualized and customized programs -- programs that differ in both content and the length of time required for completion. Third, appropriate uses of technology may have an impact on the accreditation and certification strategies which are presently in use and based on the Carnegie Unit (the time spent in study being a significant variable). Alternatively, accreditation may be based on the mastery of requisite skills and be time independent. Finally, appropriate applications of technology in education may alter the requirements for facilities. Present facilities designed to accommodate assembly-line (lock-step, cohort-processing) educational practices may unduly constrain full deployment of technologically-enhanced learning systems. To better serve the technologically-enhanced educational approaches, educational facility designs should provide for greater flexibility in use, provide for better student access to a variety of information sources within and outside the school, and be available for greater periods of time in a day and year.

The envisioned network-based learning system, described in detail in Part II, contains a methodology that allows the curriculum to be broken down into many small parts and then reassembled, under management system control, into a variety of new wholes with each able to meet a segment of currently unmet educational needs. The network-based learning system is designed to be compatible with a wide variety of industrial management tools which aid in the process of keeping the curriculum quality and currency at peak levels. Moreover, the curriculum and instructional resources may be designed in such a way that they can be managed, translated and delivered in a variety of alternative forms (for example: English or French, metric or Imperial) thereby having a potential for serving a more diverse population.

Part II concludes with a plan for development of a network-based learning system in phases with the system in the fourth or final phase capable of delivering educational services through schools, regional learning centers, or directly to users in their homes or elsewhere.

Technologically-enhanced learning systems may both increase productivity and provide products for export.

A fully-fledged network-based learning system could have some interesting spin-off benefits. First, the network-based learning system management software would be highly generalizable and marketable and applicable to any educational enterprise from elementary to post-secondary levels. Second, courseware developed as a part of the network-based learning system could be marketable. Finally, the owner of a network-based learning system could market an educational service far and wide.

Productivity is measured in terms of both quantity and quality -- more and better.

The network-based learning system, described in detail in Part II, has been developed by the author and tested in a limited way in a manual mode where it proved to be exceedingly effective. Linked with current technological potentials, it could contribute to a quantum leap in educational productivity. This vision of education in the future is presented to provide the basis for some solid planning of the right uses of technology in education. Needless to say, there are many other visions that could be projected. However, no vision of technology in the future (no matter how clear and compelling) can become a reality without substantial front-end policy setting, planning and development. This book provides a broad plan and some specific tools for getting a part of the job done. The network-based learning system is not a turn-key package ready for delivery. It provides a tool kit. The route to follow in the future must first be decided and the tools then used to fashion the desired products. Education and technology seems to be at a crossroads. If this book helps to increase the probability of choosing a new direction, or getting a better educational delivery system developed, then it has served a useful purpose.

Introduction to Part I

Where Are We Going?

Part I represents a reconnoitering phase -- an assessment of where we have been, the resources presently available, and the direction we might follow in our continuing journey. It does this by: (a) looking at some of the long-term trends impacting education; (b) using three scenarios developed by Norman Henchey (1986c) to organize and interpret the information gleaned from the trends analysis; (c) identifying and analyzing a number of contemporary factors and issues with a potential for influencing educational directions in the future; (d) assessing the resources that are presently available, and (e) developing an image or vision of the future of education which might be used to guide today's educational planning. Part II describes a technologically-enhanced learning system that could be used as we journey along. The learning system is designed to use the resources available today but to use them in a way that will make education in the future both more efficient and more effective.

This reconnoitering phase of our journey is intended to help educators get their bearings and orientations, to identify and assemble the resources necessary for our continuing educational journey, and to set some new directions.

Chapter 1 describes some of the route that has already been travelled. It picks up some of the long-term and shorter trends which are shaping society and education.

Because scenarios make it easier to interpret and understand trends and their possible implications for us, *Chapter 2* presents several scenarios and attempts to provide frameworks which help us to organize and understand the impacts some of the more obvious trends are having, and will continue to have, on education.

The way the future unfolds is determined not only by long-term trends but by a number of contemporary social and educational issues -- issues which can quickly escalate or decrease in importance but which must nevertheless be considered. *Chapter 3* identifies and discusses a number of these issues.

Chapter 4 integrates the information presented in the first three chapters into a new scenario with the view to making some choices and setting some educational directions.

Chapter 5 presents an inventory of the resources which are available today to help the educator along the way. While many of the items in the inventory have been available to educators for a long time, some new applications are suggested.

With these resources and new applications identified, together with a clear understanding of the long-term trends, contemporary issues, and constraints on education, ***Chapter 6*** presents a new vision -- some new destinations are suggested and some new avenues or approaches are discussed.

Chapter 1

Major Trends and Developments in Society and Education

The traveller, from time to time, looks up from the path being followed both to the horizon ahead and to the path behind in order to judge progress or to choose an altered course. While the horizon changes with each step -- and some travellers may be satisfied simply to amble towards those horizons facing them -- it is more likely that most travellers have destinations in mind that can only be reached by relying on the charts, maps and descriptions of these destinations developed by others.

For each of us our education is a bit like a journey or a pilgrimage with the ultimate destination being far beyond the immediate view of us or our students. Such a journey to a far off destination requires considerable speculation about what lies beyond the horizon and it is only after a destination and the intervening terrain have been clearly envisioned that specific steps can be planned and taken to reach that destination. Towards this end, this chapter identifies some of the major trends that have shaped, and continue to shape, society and education.

A Look Into the Rearview Mirror

Our history -- that terrain which has already been traversed -- may be broadly described in terms of four periods: the Nomadic Period (pre-8000 BC), the Agrarian Period (8000 BC to 1700 AD), the Industrial Period (1700 AD to 1955 AD), and the Post-Industrial (Information) Period (post-1955 AD) (Toffler, 1980: 13-14). As one examines these periods in more detail it becomes apparent that the transition from one period to the next was precipitated by advances in technology and each technological advance altered the societal base of power and the way education was provided.

The ***Nomadic Period*** was characterized by people fully occupied with the gathering of food necessary for survival. Because of the migratory nature of wildlife and the seasonal availability of plants, these people were perpetually on the move. As might be expected the base of power in the nomadic clans or tribes was founded on hunting and food-gathering skills and inasmuch as these people were fully engaged in these activities as a matter of survival, there was little opportunity for anyone to divert precious time away from these activities in order to plan a better way of life. The nomads' technology was simple and consisted of their food-gathering tools and skills and these tools and skills were passed from parents to children.

The ***Agrarian Period*** supplanted the Nomadic Period as some of the nomads learned that they could cultivate the land and grow crops, thereby ensuring their food supply. To cultivate the land and to grow crops required manpower (brawn). The more land available for cultivation, the more manpower one could support and the more power one had. As a consequence of land owners being able to produce more food than needed, some land owners were able to enjoy a degree of leisure or free time and this free time gave rise to activities that enabled the agrarian society to begin to transcend itself (to attain higher levels of achievement). For the agrarian, technology consisted of primitive agricultural implements and the skills required to use them. As with the nomads, education consisted of passing skills from parents to children. The transition from a nomadic to an agrarian economy, and the accompanying improved lifestyle of the agrarians, wasn't obtained without social costs. The land claimed by the agrarians would have been some of the same land traversed by the nomads in their quest for food and the settling of this land placed restrictions on their hunting territory and this often resulted in conflicts.

The ***Industrial Period*** was heralded in by the invention of powered machines capable of replacing human brawn in the workplace. These machines cost money with the result that capital replaced land as the principal base of power. The widespread use of machines gave rise to assembly line production and an accompanying division of labor. Just as the farmer claimed the land used by the nomads, so industries uprooted people and drew them away from the land. People tended to move to where jobs were available with the result that the extended family, which was the norm in the nomadic and agrarian periods, declined and the nuclear family emerged. For industrial man, technology meant machines to power the factories. Because this technology was not used within the family unit (as was the case with the nomads and agrarians), children had to be prepared for their roles as industrial men and women by attending schools.

With the significant advances in transportation, communications and technology that gave rise to the further development of machines that could operate other machines (i.e., computers) came the ***Post-Industrial (Information) Period***. Whereas the machines of the industrial period provided a substitute for human brawn, the machines of the post-industrial (information) period serve as a substitute for human brain power. Power now appears to be vested in information and knowledge (Naisbitt, 1982: 7; Science Council of Canada, 1982: 10). Again, the emergence of a new period is associated with conflict and social turmoil. In the present case machines are replacing people (especially the blue collar and white collar workers). Technology, in the form of information and information processing, has eliminated many of the assembly-line jobs from industry. Remaining are the menial and service jobs and the highly skilled jobs and for the latter training is both difficult and unique. Even schools have difficulty in meeting the diversity of educational needs imposed by modern society.

This sweep through our history seems to point to one conclusion. Technology, in whatever form it takes, seems always to change the nature of work and the way people do the work. Equally important, changing the nature of work changes and the way it is accomplished changes that way a society's wealth is distributed (i.e., wages). These changes seem to first result in a tug-of-war between economic fluctuations and political reactions and then in widespread social reverberations.

Half of our general knowledge base has been developed since 1957.

Through this brief review, one also begins to sense the accelerating rate of change we are now experiencing. This accelerated rate of change becomes very apparent if we note the exponential rate of social change as seen in the numbers of first patents for inventions granted by the U.S. Patent and Trademark Office. That agency reports that only one patent was issued in 1836, the first year that patents were issued. By 1986 approximately 220 million first patents had been issued in the United States and one half of these have been issued since 1957. If patents are taken as a reasonable indicator of increases in societal knowledge, then one might conclude that half of our general knowledge base has been developed since 1957.

A detailed examination of our more recent history reveals several other important trends: trends that seem to be creating a pressure for change in education.

Some Recent Trends

The rate of change accelerates geometrically.

During my early years, spent on a farm in northern Alberta, travel was limited and we had no powered machines to help with the work. (Rural electricity in that area was still far in the future and cars and tractors were both scarce and expensive.) Now as I sit at my personal word processor in the comfort of my home, I am aware that I have access to scores of machines and appliances: cars, power boats, snow blowers, lawn mowers, hedge trimmers, food processors, microwave ovens, hair dryers, calculators, dishwashers, washing machines, dryers, radios, televisions, and on and on. In retrospect, it is easy to see that I have stepped from the agrarian era into the post-industrial (information) era, and almost overnight. The surprise is that it is only in looking back that I am able to discern some of the trends that have had an influence on me.

Technological Trends

The speed of travel has increased 400-fold in this century.

Travel. Travel has always been a key to communications and until the invention of the steam locomotive in the early 1800s, travel was from the earliest times limited to the speed of walking (or riding if one had an animal of burden).

With the coming of the locomotive the speed of travel increased approximately ten-fold (from three to four miles per hour to 30 or 40 miles per hour). The internal combustion engine invented in 1885 gave rise to the automobile and the airplane (the latter attaining speeds approaching 300 miles per hour) and a further increase of speed by a factor of ten. The development of jet engines in 1950 again more than doubled the speed of travel. By 1957 rockets had escalated the speed of manned travel to more than 20,000 miles per hour (about ten times faster than the speed of a rifle bullet). Until the invention of the steam locomotive, the speed of travel was limited to that of walking. In the first one hundred years following the development of the steam locomotive, the speed of travel increased from that of walking to that of the early automobile or airplane (about 50 miles per hour). In this century the speed of travel has sharply escalated from approximately 50 miles per hour to more than 20,000 miles per hour (e.g., manned space craft).

Communications networks provide global coverage, live and in color.

Telecommunications. A second important trend to observe is that of telecommunications. Until the development of the printing press in 1440, almost all communication was by means of the spoken word. The printing press not only enabled widespread use of books, it provided an easy means for information storage. The discovery of electricity paved the way for a number of other communication breakthroughs -- the telegraph, the telephone, the radio, and the television. Communications technology coupled with the speed of rockets provided us with communication satellites. With each new communication breakthrough came an increase in the number of people that could be included in the communication coverage pattern. Today's communication satellites have coverage patterns that provide hundreds of millions of people with full color, live, television programs. Indeed, the Vietnam War became known as the "living room war" because people watching the evening news via satellite on one side of the world were able to witness first hand the carnage taking place on the other side of the world. What a far cry from the communications available during my youth. Back then the itinerant pedlar, the mail-order catalog and the annual almanacs provided our only exposure to the world outside our community.

Computers. A third trend to be assessed for its potential contributions to social and educational change is computer technology. Though the logic of computers was understood for some time, it wasn't until after the development of the triode tube (1907) and the transistor (1948) that computers, as we know them, became a reality. Transistors might be thought of as one-bit chips. Two transistors were successfully combined into a single two-bit integrated chip in 1959. By 1976 chips were able to hold 20,000 bytes (i.e., 20K (kilobyte) chips). Chips with a 64K capability were available in 1980. By 1982 the chip density had increased to 256K. Manufacturers now build computers on chips the size of postage stamps but with power in excess of computers that occupied the space of a whole room only a decade ago and the cost of computer memories is dropping sharply.

The cost of computer memory rapidly approaches zero. Manufacturers may soon be giving computers away.

Noyce (1977) reports per bit costs of computer memory to have been: approximately 0.45 cents/bit in 1K chips (*circa* 1973), 0.15 cents/bit in 4K chips (*circa* 1975), 0.05 cents/bit in 16K chips (*circa* 1980), and 0.02 cents/bit in 65K chips (*circa* 1982). More recently, the Microelectronics and Computer Technology Corporation predicted that they will be able to extend today's capability for designing logic chips with 200,000 devices to chips with 10,000,000 devices by 1990 (Fischetti, 1986:76). The Science Council of Canada (1982:15) predicted that the cost of computers by 1990 will be 1/400 the price of computers in 1982. Taken together, these observations and predictions suggest that 256K of random access memory (RAM) which may have cost $11,529.00 in 1973 and $768.00 in 1982 will cost about $1.92 by 1990. Indeed, computing hardware is so rapidly approaching zero cost that manufacturers may soon be giving away computers so that they can establish the broad base of need necessary to support development of the somewhat more expensive software, information bases, and related resources.

In conjunction with advances in computer technology one finds artificial intelligence -- another rapidly developing phenomenon that must be watched because it could have a great impact on education in the not too distant future. Artificial intelligence means programming a computer to do a variety of complex tasks such as: act as an expert system (by building a knowledge base); process oral or written language; or, process optical images (Brady, 1986: 26-29). An expert system is, "... a computer program that emulates the decision-making ability of a human expert in some field" (Thornburg, 1986:55) and as such it could serve as an "intelligent coach" in developing individualized educational plans or in leading a student through a problem-solving strategy, analyzing incorrect responses, and deducing from those responses where the student went wrong. The expert systems may even be able to identify alternative approaches to help floundering students get back on track (Brady 1986: 28).

Lasers and laser printers represent still another interesting micro-trend: interesting because their development so clearly portrays the rapid rate of technological change. The principles of electrostatic (dry) copying were formulated in 1938. Dry copiers entered the marketplace in 1959. Laser copiers were conceptualized in 1971 and by 1977 were operating at speeds of two pages of copy per second. The first few technical papers on semiconductor lasers were published by Japanese and American scientists in the period 1968-70. By 1983, the volume of papers on lasers produced by these countries had grown to nearly 3,500 per year (Bell, 1984). These technical papers represent just one example of the explosion of specialized publications included in Naisbitt's (1982: 16) estimate that 6,000 to 7,000 scientific articles and technical papers are published each day. Now laser printers coupled with computers might be relied upon to deliver high quality hard copy documents (distance education learning modules, for example) over great distances and with great speed.

Besides these technological trends, there are a number of other trends and developments which are of significance to education.

Industrial models have potentials for application in education.

Industrial Models and Management Systems

An increasing number of management tools and techniques have been developed in both industry and the private sector with a potential for increasing educational quality and productivity. While many of these tools and models may not be directly applicable to education, some may warrant further consideration with an expectation that some elements may be borrowed and used in education. Among the more promising of these tools are those that facilitate planning, decision-making, program or project implementation, and quality control. Specific tools and models include: flow-charting, networking and project management strategies, operations research, reliability and quality control, human factors analysis, value analysis, and planning and evaluation systems.

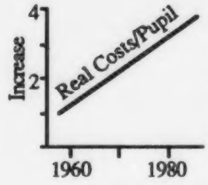
Competition

Henchey (1986a) identifies competition as a growing force and contends that competitiveness will play a key role in shaping education in the future. First, graduates of the educational institutions must be able to take up the reins of the economy and maintain its competitiveness in a world market. These graduates, at least some of them, must be entrepreneurs. Second, though education has long been regarded as a public enterprise, public education must be able to compete in serving students. The last 50 years has seen a rather significant increase in the number of minority groups in the general population. This cultural pluralism creates a demand for private or alternative educational delivery models. With the cost of computers dropping and the increased availability of high quality communications technology (and especially tools such as artificial intelligence), it is conceivable that the private sector could begin to offer quality educational programs thereby further increasing the competition in the educational arena. Scharf (1988:11) asserts that, "There is a way of ensuring efficiency in education -- let the market decide which schools to support." Schools in the future may survive solely on the basis of alternate delivery modes, high quality educational outcomes, and good marketing.

Demands for Accountability

The quality of education is a matter of public concern.

The accountability issue emerged in the 1960s and early 1970s and today the public continues to be concerned about the rising costs of education and declines in educational productivity (falling Scholastic Aptitude Test (SAT) scores, for example) and it is beginning to clamor for greater educational accountability (Henchey, 1986a).



A study (Clarke, et al, 1977) compared Grade 3 students in an urban Canadian setting with their counterparts from 1956 by using the same test instruments and norms. The results of the study were used as the basis for arguing that educational productivity hadn't declined; that the students in 1977 did as well as the students in 1956, except in arithmetic (i.e., the scores of both groups on five tests were within an average of three percentage points of each other). An examination of other data reveals that educational costs (in real dollars) during the 1956-77 period had increased by a factor of three while the pupil-teacher ratio had declined from 25.5 pupils per teacher in 1956 to the range of 18:1 in 1977. Scharf (1988: 11) cites evidence that, "... Canada spends more per capita on education than any industrialized country in the world". The National Center for Education Statistics (1985:21) reports similar trends in educational costs elsewhere in North America. Perelman (1988:21) makes a statement that serves as an excellent summary, "Total education costs per pupil, in constant dollars, have nearly quadrupled since the early 1950s, without any evidence of a proportional improvement in scholastic performance. The inescapable conclusion is that the productivity of education has been declining". On the basis of the increased resources devoted to education, it would have been quite reasonable to expect today's students to outperform their counterparts of the early 1950s. On the other hand, it may be that there were some desirable educational outcomes which were not measured by the achievement measures used.

Educational decline is linked to:

- *simplified texts*
- *course discontinuities*
- *inadequate standards*
- *deemphasis on writing.*

Declining Scholastic Aptitude Test (SAT) scores have been acknowledged for some time. Beaton, Hilton and Schrader (1977) documented the trends from 1960 to 1972. Cetron (1984: 44) and Christiansen (1985: 33) observed that the decline continues. Harold Howe II (1986: 18-21), in an analysis of factors contributing to the declining SAT scores, concluded that 50 percent of the decline was attributable to a change in the composition of the test-taking group over the years. A further 25 percent of the decline was found to be related to broad social issues: the effects of television, the effects of life in single-parent families, the effects of being latch-key children, and the effects of national traumas -- the threat of nuclear war, the Vietnam War, civil rights unrest, and so forth. The final 25 percent was found to be related to school-based factors: simplification of textbooks, declining integrity and continuity in courses of study, failure to establish adequate standards of learning, and insufficient emphasis on writing skills.

While educators may be relieved to learn that they are not being held totally responsible for these declines, the public isn't so well informed. The public still perceives educational outcomes as being in decline, educators as accountable, and they expect improvements. A number of informed observers of the educational scene, for example, Goodlad (1984: 1), Adler (1986), and Finn (1987: 2) confirm the public's poor assessment of education and declare that they too believe the public education system to be in serious trouble.

Sadly, attempts to reverse the trend of declining SAT scores are complicated by the fact that the average SAT score for those entering the teaching profession (i.e., SAT = 812) is below the average for many other professions (e.g., engineering SAT = 987) and the average for all students who took the test (i.e., SAT = 893) (Cetron, 1985: 113). A report prepared in July 1984 (Darling-Hammond, 1984: 2) makes the same point on the basis of an analysis of SAT scores for the period from 1973 to the early eighty's. A Canadian analysis revealed similar patterns (Violato, 1986:1-3). Education as a profession seems to lack the prestige, and perhaps the salaries, necessary to attract the excellent candidates that are required if education is to lift itself out of its problems by its bootstraps (Leu, 1986).

Educational budgets are often set to outstrip neighboring districts in terms of per pupil expenditures.

There may be other reasons for spiralling educational costs. First, education has no competitors with the result that there are no valid productivity comparators. Second, education is labor-intensive and teacher representatives at the collective bargaining table are reluctant to yield hard-won gains in this area. Third, a significant contributor to the high cost of education is the fact that a great deal of computer hardware, software and human resource development (in-servicing) has been layered over top of an already costly, labor-intensive, educational delivery system. The private sector practice of trying to substitute one factor of production (e.g., capital, such as robotics) for another factor (e.g., labor) in order to increase productivity or to reduce costs, or both, is not frequently encountered in public education. Finally, it is not too surprising to see the costs of education spiralling when one sees governments and school districts applauding themselves when in comparison to other districts they can claim the lowest pupil/teacher ratios or the highest per capita spending on education. The problem is that neither increased educational spending nor lowered pupil/teacher ratios can be clearly shown to have a direct positive relationship to student achievement. Indeed, the situation is somewhat analogous to a group of shoppers gathering after a shopping trip and comparing prices paid for identical loaves of bread in order to determine who had managed to spend the most for their loaf and therefore had the "best" loaf. The private sector practice of trying to get a quality product at the lowest possible cost is not often considered in education.

Transformation of Knowledge

Henchey (1986a: 5) observes that:

Information joins land, labor and capital as a fourth factor of production.

> *There is a revolution taking place in knowledge and its role in society. This includes: an information explosion in almost every academic and professional field, expanding bodies of data* [including personal information], *technique and theory; improvement in our methods of acquiring, storing and controlling information; increasing speed of dissemination to the public, changing the context of 'knowledge work' and 'knowledge industries'; and, at a deeper level, the transformation of paradigms, models and assumptions ('new' physics, critiques of rationality and technology, studies in artificial intelligence). What land was to a pre-industrial society and money was to an industrial society, knowledge is to a post-industrial society* [added by author].

Economic/Political Instability

Changing the way work is done changes the distribution of national wealth.

Technology seems to change the way work is accomplished in a society and this in turn alters the way in which a nation's wealth is distributed. For this reason, the economic structures and concepts that were developed to serve an industrial society (land, labor and capital are the only factors of production, for example) may be severely shaken in the societal restructuring that is imminent or already occurring. Naisbitt (1982) makes a strong case that information (the ability to get it, process it and use it) is a fourth factor of production -- and perhaps among the most important. Moreover, because the economic model currently in vogue is not as effective as it could be in working out the relationships between inflation and unemployment, and because a number of financial institutions, and even nations, have become very shaky, there is a nervousness and concern about economic and financial matters. The March 1986 drop in world oil prices and the October 1987 perturbations in stock markets around the world illustrate how much sensitivity and instability there is in the economic system. This may have the effect of placing even greater emphasis on educational accountability.

With technology changing the way people work and the way a nation's wealth is distributed (i.e., it changes wage rates and it changes who receives wages) it also produces political overtones. Indeed, technology can be seen as triggering economic impacts which in turn become political issues. The resultant political interventions may trigger further economic impacts and the economic/political reverberations continue.

Integration

Integrate:
- *curriculum*
- *people*
- *planning.*

Three sorts of integration merit consideration. First the curriculum should be integrated: grade to grade, course to course within programs, and between and among courses in programs. There are some signs that the traditional content and subject-oriented curriculum may have to give way to an integrated and integrative curriculum (Nelson, 1985: 8). He contends that impacts and relationships of ideas and actions will be more important than the tunnel-vision approaches fostered by subject-area specializations. Narrow specialization often leads to nothing but sterile and inert ideas. Second, there must be integration both within and among people. The third kind of integration involves planning -- locally, regionally, nationally and internationally.

This third kind of integration (integrated planning) is important inasmuch as all contemporary experience points to the reality of an emerging world system in the widest sense and one which demands that all actions taken on major issues anywhere in the world be taken in a global context and with full consideration of the multi-disciplinary aspects. Moreover, due to the extended dynamics of the world system and the magnitude of the current and future change, such actions have to be anticipated so that adequate remedies can become operational before the crises evolve to their full scope and force (Mesarovic & Pestel, 1974: 31).

Cultural Pluralism

Within western society there is a great need to bring together people from a wide variety of backgrounds. Whether it is the American "melting pot" (assimilation), the Canadian "mosaic" (integrated parts), or any other way of including or incorporating all people into an open and pluralistic society, there must be a learned awareness of, and respect for, each other in order to allow each to make their maximum contribution to the betterment of society.

The half-life of knowledge is now in the range of five years.

This quick look back over our shoulders at both the long-term trends and some of the somewhat shorter but still significant trends and developments serves to establish one point -- change is not linear. Change is geometric and the rate of change experienced by each generation is increasing. Society's fund of knowledge has been estimated to be doubling every 5.5 years (Naisbitt, 1982: 16). Because so much of the expanding body of knowledge is relevant to each of us in our daily lives, there is a need for continual learning and without it we quickly become functionally illiterate. Indeed, Naisbitt's estimate suggests that the effective half-life of an individual's fund of knowledge is now in the range of about five years. Perhaps as much as 75 percent of the total body of societal knowledge that we have accumulated up to now is less than 10 years old. Moreover, it is reported that 90 percent of all the scientists that ever lived are alive and working today.

Heilbronner (1979: 7) makes an interesting point which serves to put this discussion into perspective:

"... Geological time has been made comprehensible to our finite human minds by the statement that 4.5 billion years of the earth's history is equivalent to once around the world in an SST.... Man got on eight miles before the end, and industrial man got on six feet before the end...."

Barriers to Educational Change

Change is inhibited by:
- *system inertia*
- *vested interests*
- *high development costs*
- *lack of competition.*

While there are significant pressures for change in education, there are also a number of barriers to change.

Educational System Inertia

With the level of teacher experience (i.e., years out of university) at about ten to twelve years (National Association of Elementary School Principals, 1984:37) and with the useful half-life of education suggested to be about five years, it is highly probable that much current educational theory is not finding its way into practice. Tobin and Sharon (1984:22) observed that in education, "New technologies are, like older technologies, being incorporated primarily as teaching aids in a largely unchanged educational system". Ferguson (1980: 280) reached the same conclusion: education is not very dynamic. Interestingly, these observers echo the findings of researchers working a decade earlier (Goodlad & Klein, 1970: 72; Shane, 1973: 329-330; for example).

Vested Interests of Teachers

Over the years teachers in most localities have formed themselves into unions and included in many of their contracts are definitions of working conditions, including specification of a pupil/teacher ratio. Unions may be expected to cling to these hard-won working conditions even though the effect may be to slow particular types of educational change. The notion of all teachers dealing with standard-sized class lots of students is probably one of the major deterrents to changed teacher roles, for example, teachers as facilitators of individualized and customized modes of instruction instead of information sources in cohort-processing modes.

High Costs of Educational Change

It must also be recognized that the high cost of technology, and the need for substantial reorganization of the curriculum to make it compatible with technology, are other factors which inhibit widespread use of technology (Miller, 1981: 18).

Lack of Competition

Education is somewhat unique in the fact that it is almost wholly funded from public funds. As a consequence, the practitioners and professionals in the field (local, district, state/provincial, federal) are all civil or public servants and they serve a captive audience -- laws and statutes require students to be in schools until they reach a certain age. The problem with all of this lies in the fact that nobody has responsibility for ensuring that educational practices utilize the latest knowledge and tools. Indeed, educational budgets are often set, not by asking, "What is needed?" but by attempting to exceed or equal what others are spending on education. Plaudits are afforded to those who spend the most.

Unhappily, the incentives to do otherwise are lacking. In many instances savings derived through good fiscal management are not available for use in other needy areas or alternative applications -- the savings are required to be returned to central treasuries. Lacking appropriate incentives, it is not surprising that no one makes consequential decisions to improve educational productivity. Nobody weighs the factors of production (land, labor, capital, information) and proposes substitutions in the mix. The resultant is that educational costs continue to spiral and educational productivity continues to decline.

Other Barriers

There are inadequate rewards for educational innovation.

Leu (1986) identifies several other barriers to change: (a) inadequate incentives and rewards for change/improvement; (b) inadequate "climate" to encourage and reward risk-taking necessary for change; (c) inept "processes" for causing and sustaining significant change (affirmed by Wolcott (1977: 239-246)); and (d) inadequate preparation programs for teachers and educational leaders in the causing and sustaining of educational change.

Summary

This chapter has identified and discussed some trends and developments impacting education in order to understand where education is and where it has come from. Based on the belief that the future can be altered by decisions made today, these trends and developments have been identified in order that some scenarios may be constructed and their implications considered in the next chapter. If preferred scenarios can be developed (scenarios preferred by a majority in the educational arena) then it may be possible to develop plans and initiatives to ensure their unfolding.

Chapter 2

Possibilities: Images of the Future

Understanding the Pressures for Change

Small pressures for change may emanate from many sources, combine with others, and grow.

Societal change seems to contain elements of at least three kinds of interacting forces or trends. First are the long-term technological forces or trends which drive change, and if hindered in any way, result in a build-up of pressure that inevitably breaks through on society like water breaks through a dam (pressures emanating from the "Impetus Range" as illustrated in Figure 1). Second, are the shorter economic/political trends (pressures from the "Repercussion Range"). As the technological forces advance and alter what society does, how it does it, and how wealth is distributed (e.g., changes in the wage structure), economic/political structures are often tested and found wanting. The resulting corrective and reactive measures spawn a third set of trends, those short-term trends related to social change (and flowing from the "Reverberation Range"). A clustering of these three kinds of trends or forces gives a hint as to the type of educational system that might emerge if any of the following clusters of forces remained intact and relatively immune to other competing forces while at the same time exerting their full force on reshaping education.

The Technological Cluster (*"Impetus Range"*)

The potentials available from industrial models and the use of technology (communications, computers and artificial intelligence) to extend human capabilities in areas of thinking, problem-solving and managing are staggering. Education could be affected as profoundly by these phenomena as is the case in the marketplace. Competition represents a third related dimension. Competition may be described as both the need for maintaining a competitive economy and also competition within the educational arena -- especially by private schools and private sector enterprises.

The Economic/Political Cluster (*"Repercussion Range"*)

Demands for educational accountability and the encouragement for the application of cost-benefit equations to education are based on the belief that education should be more productive. This belief is being translated into pressure for educational change and aligned with concerns about the economic instability or turbulence evident in most sectors of the economy.

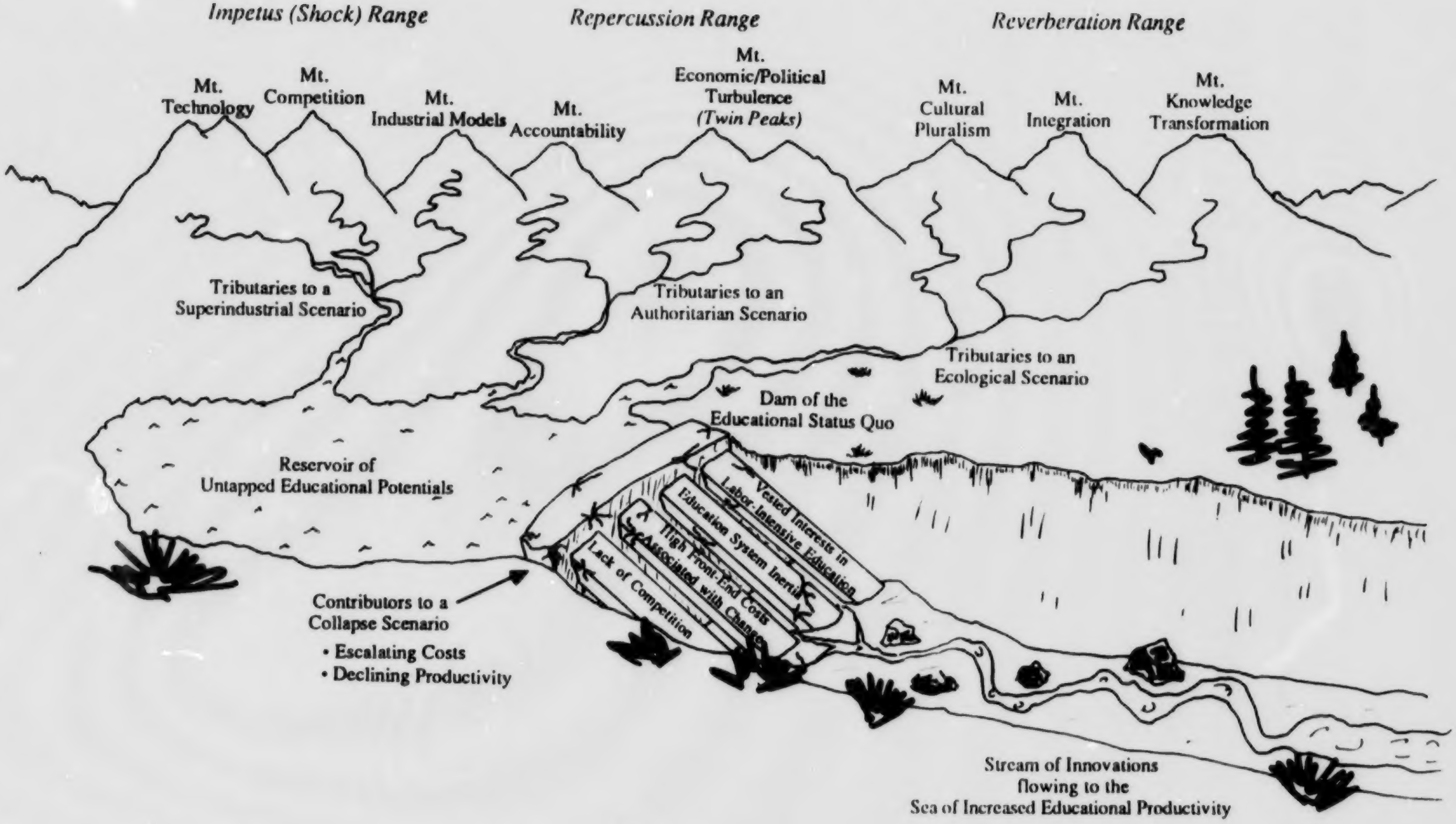

Impetus (Shock) Range
Repercussion Range
Reverberation Range
Mt. Technology
Mt. Competition
Mt. Industrial Models
Mt. Accountability
Mt. Economic/Political Turbulence (Twin Peaks)
Mt. Cultural Pluralism
Mt. Integration
Mt. Knowledge Transformation
Tributaries to a Superindustrial Scenario
Tributaries to an Authoritarian Scenario
Tributaries to an Ecological Scenario
Dam of the Educational Status Quo
Reservoir of Untapped Educational Potentials
Vested Interests in Labor-Intensive Education
Education System Inertia
High Front-End Costs Associated with Change
Lack of Competition
Contributors to a Collapse Scenario
• Escalating Costs
• Declining Productivity
Stream of Innovations flowing to the Sea of Increased Educational Productivity

Figure 1. A depiction of forces and factors influencing education today.

The Social Cluster (*"Reverberation Range"*)

The need for accommodating cultural pluralism and for multi-dimensional integration are raising the prospect that educational content and delivery must change in order to meet the new demands -- the old educational content and delivery patterns may not be sufficiently effective. This need for change is further advanced by the changing role of knowledge in society. Some (e.g., Naisbitt, 1982) regard knowledge as being roughly equivalent to other factors of production (i.e., land, labor and capital).

Possible Scenarios

Images of possible, probable or preferable futures may be projected, proposed, or planned.

Allain (1979: 21) describes three types of futures: the possible, the probable and the preferable. Henchey (1986c: 3) contends that there are at least three ways of developing an understanding of the future: through projected images, proposed images or planned images. All three types of images help us to see something down the road that we may want to achieve and they help us understand the types of planning that might occur or the types of interventions that might be made in order to attain a desired goal. Images of the future are important. A prophet once declared, "Without a vision, the people perish" (Proverbs 29: 18). This view is echoed by Polak (1973: 19) who suggests that without a positive and flourishing image of the future, cultures and societies decay.

Henchey (1986c: 4-5) has considered these clusters of forces, worked through some of their impacts on education, and developed three "images of the future" which he labels the "Superindustrial Scenario", the "Authoritarian Scenario" and the "Ecological Scenario". A fourth image may be developed if one regards the cracks in the dam (escalating costs and declining productivity) shown in Figure 1 and observes the rising pressure for change. The name of the fourth image could be "Crisis" or "Collapse" and the collapse could occur because of the increasing or expanding forces. As with all expanding forces (especially those which grow at a geometric rate) the point soon arrives when no opposing force or forces can contain them.

Allies of the status quo:

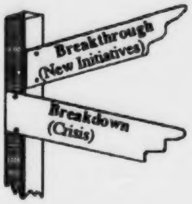
- *inertia*
- *vested interests*
- *high costs*
- *lack of competition.*

Right now there appears to be four major forces opposing significant educational change -- the inertia of the educational system, the vested interests teachers have in preserving the current labor-intensive mode of educational delivery, the high costs associated with any substantive change in education, and the lack of competition in the educational arena.

The trends and scenarios considered to this point suggest that many forces are at work in our society and some are beginning to produce a pressure for change in education and, as illustrated in Figure 1, these forces may begin to combine. While it is possible at this point to identify and describe the different pressures at work, it is impossible to predict which pressure or pressures will be most instrumental in changing education (bursting the dam) or when the changes will occur.

To do nothing in the face of the problems confronting education it to court disaster.

Before one can address the impacts these scenarios could have for education, it is essential to examine a number of other forces and factors which (while not directly producing a pressure for change) have a potential for influencing or shaping educational directions. As this examination is undertaken it must be kept in mind that the "crisis" scenario is a do-nothing scenario -- it could occur through inaction. The Communications Era Task Force (1983:4) puts things into perspective.



> *Each crisis we face is both a problem and a hope, a challenge and an opportunity. As we leave today's crossroads, we can rush down the path of breakdown or turn the corner toward breakthrough.*

Summary

Three scenarios have been advanced by Henchey (1986c): the Superindustrial Scenario which would lead to a very business-like educational system, the Authoritarian Scenario which would lead to a very autocratic system, and the Ecological Scenario which would be a very humanistic system. If education is in the sad state suggested by Goodlad (1984: 1), Finn (1987: 2-5) the National Governors' Association (1986: 2), and others, then the Collapse Scenario might also be a possibility.

Prior to further analysis of these scenarios, the context of education is further examined. The next chapter is devoted to a review of a number of contextual forces and factors capable of shaping, to some extent, the way education evolves in the future.

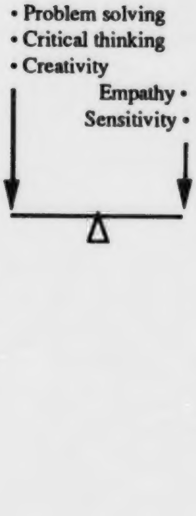
Chapter 3

Forces and Factors Capable of Influencing Educational Change

Our nomadic and agrarian ancestors had hundreds, and perhaps thousands, of years to adjust to the changes in their society. In the latter part of the industrial period the changes began to occur more rapidly and people had to learn to adjust to a number of them in a lifetime. As we enter the post-industrial (information) period, the rate of change has now reached a point where major shifts in society have to be accommodated in just a few years (sometimes even months).

Clearly, the direction society follows is shaped by a great many simultaneously occurring phenomena. The same is true of education and, indeed, there are a number of forces and factors (or issues) now visible that appear to have a capability for influencing or shaping education in the future. The more obvious of these forces and factors are outlined in this chapter.

Goals of Education



One of the current demands placed on education is for an integrative education -- a multi-disciplinary approach partly centered on problem-solving and coupled with development of the intellect for creative and constructive thinking. Education must also be centered on the development of empathy and a sensitivity which will prevent one from dismissing matters of human value. It is a matter of balancing these two because if we pay attention to only one, the other will necessarily remain underdeveloped. Both are required for the development of "intelligence", properly speaking. Both involve ways of knowing into which children should be initiated. Both should be part of the deliberately planned learning which is too important to leave to chance in the environment of the general culture. Deliberately planned learning -- with a curriculum and a suitable physical environment -- is the very reason for which we have schools. They provide the environments in which we make it easier for children to develop their own minds and find their own insights into the truth of things. Part of what educators should be doing is to encourage students to work out for themselves the ways of testing different kinds of truths in various aspects of their lives, in supportive relationships with their peers and teachers, and with the knowledge support systems in a physical environment which encourages discovery of all kinds. These shifts in the goals of education demand: all-encompassing and integrative approaches to both problem-solving and dealing with people; lifelong learning; learning to learn; development of an inquisitive and innovative spirit in students; and, individualization so that each person can develop to his or her own potential. At the same time students must come to understand their need for interdependency and social values and skills.

Education is becoming less a matter of individual choice and more a matter of social demand.

Another way of looking at the goals of education is to consider them on the basis of an individual choice/social demand continuum. Traditionally, individual choice has played a large part in determining curriculum content. There are now some signs to suggest that the curriculum content might become more closely geared to social demands. As one example, the government of a Canadian province recently distributed a position paper on economic development that recommends both economic education and entrepreneurship as components of the curriculum (Government of Alberta, 1985: 67).

Curriculum

Students must learn to manage information -- acquire it, evaluate it, and use it.

As a result of the current explosion of knowledge identified and described by Naisbitt (1982:16), the whole concept of subject-oriented programs in schools is called into question. A more practical approach to education may be to describe a core curriculum consisting of basic reading, writing and mathematics (Cetron 1985: 3) and directed at helping students to learn how to acquire, evaluate and use information which will help them meet their individual objectives. (Evaluation of copious amounts of information will be imperative in the future and students should develop a healthy skepticism so that they choose only the most useful information.) The Communications Era Task Force (1984: 11) itemizes a number of values which will become even more essential tomorrow than is the case today, values such as: honesty; responsibility; humility and love; recognition of interdependence and interconnectedness; understanding that all actions have mixed consequences; cooperation; appreciation of diversity; and authority based on competence, knowledge and wisdom rather than force. With these skills and values students may pursue learning for a lifetime, augmenting their knowledge, skills and abilities as needed.

These skills and values may be most readily acquired in an educational program of the type advanced by Miller (1981: 20). We must create an educational program that carries students:

From ...	***To ...***
• *Mass teaching*	• *Personalized teaching*
• *Single learnings*	• *Multiple learnings*
• *Passive answer absorbing*	• *Active answer seeking*
• *Rigid daily programs*	• *Flexible schedules*
• *Training in formal skills and knowledge*	• *Building desirable attitudes and appreciations that stimulate a questing for knowledge*
• *Teacher initiative and direction*	• *Child initiative and group planning*
• *Isolated content*	• *Interrelated content*
• *Memorized answers*	• *Problem awareness*
• *Emphasis on textbooks*	• *Use of media in addition to texts*
• *Passive mastery of information*	• *Active stimulation of intellect*

Future generations may be vulnerable to the societal equivalent of Alzheimer's Disease.

Trying to maintain the curriculum apace with an exponentially expanding body of societal knowledge poses some very real problems in priority setting. As a way around these problems, the prevalent solution is to delete parts of the curriculum that seem to be of least importance. Often the parts that are deleted pertain to our historical and cultural heritage. Making room in the curriculum for new knowledge by eliminating these other pieces of knowledge is risky. If students in any generation fail to acquire a reasonable understanding of their history -- if they cannot remember the past -- they risk becoming victims of malady similar to amnesia or a social form of Alzheimer's Disease -- they risk repeating the mistakes of earlier generations. The implications of a society losing its memory would be devastating. It is important that we develop a firm understanding of our history through the curriculum.

Technology demands a modularized curriculum.

Finally, the curriculum needs to be restructured to make it compatible with technology (Charp, 1988:32). This means breaking the curriculum into manageable pieces and clearly describing the relationships the pieces have to each other.

Societal Values

Evidence is beginning to accumulate to suggest that the traditional work ethic (i.e., hard work and delayed gratification) may be shifting toward instant gratification and a regard for work as but one of a range of options (Morrison, 1979: 158-162).

In addition, there is a shift in core societal values that may be precipitating a further rise in the establishment of private schools. This may be due, at least in part, to the rejection of values associated with situational ethics and secular humanism in favor of the more absolute values contained in Judeo-Christian teaching. The Moral Majority in the United States (which was extremely influential in obtaining Reagan's election) may be a major factor in reshaping values in this domain in the future. The major spokesmen for the Moral Majority, and a number of other similar voices, have full media capabilities including their own satellite channels. This provides them with an unusually strong potential for further changing societal values.

Life-long Learning

If the useful half-life of our education is in the range of five years, it is plainly evident that there will be a great need for re-educating a significant portion of the population (perhaps several times over). For many people whose formal education ended in the public schools, their re-education may begin at the same level. Similarly, universities may be expected to retrain their graduates.

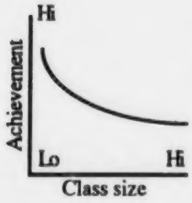
Leisure time is also increasing. While the nomads had none and the agrarians relatively little, industrial man works only 35 to 60 hours per week and thus has some leisure time. Predictions are that people in the post-industrial (information) period will have even more leisure time and educational institutions may be expected to provide educational programs to occupy at least part of this leisure time.

Individualization of Learning

In many ways the industrial period was characterized by standardization. Manufacturing took place on carefully designed assembly lines. Parts were standardized and put together by people following pre-defined steps. As workers left the assembly lines others replaced them and the assembly process continued uninterrupted. Now computers and robots are performing many of the assembly line routines. Skilled people are engaged in more individualistic activities. As a consequence the educational needs within the factories are changing and the school as a factory producing standardized products for an assembly-line world may be no longer viable. Schools must somehow learn how to meet the individual needs of its clients.

On examination of the current philosophies of education (i.e., the philosophies of teachers, schools, or school districts) one almost always finds the student at the center -- education should meet the individual needs of students. Unhappily, as Goodlad and Klein (1970: 72) and many other critics have observed, instances of individualized instruction are scarce. Digging a little deeper one discovers that individualized instruction is not found in most schools because teachers lack the classroom management tools needed to make individualized or independent instruction work.

Toffler (1970: 266-267) advanced the view that technology has the potential for widespread individualization of education in much the same way that it allows you or me to have an assembly-line car that is different from any other car produced on the assembly line. (The combinations that can be created from the multiplied choices of color, body design, engines, transmissions, options and add-ons are staggering in number.)



Individualization of instruction is an ideal which should be pursued and for a very good reason. Literature on the effects of class size suggests that students presently performing near the 50th percentile on standardized tests, while in classes of 35 students, would rise to the 60th percentile in a class of 20, to the 65th percentile in a class of 15, to the 82nd percentile in a class of five, and to almost the 90th percentile in individualized or very small group settings (Glass, et al, 1982: 49). If these findings are even close to being accurate, the potential improvements in educational productivity which could be achieved through individualized instruction are staggering.

Teachers need tools that enable individualized instruction.

Although little has been accomplished by way of bringing computer and communications technology to bear on the problems of individualization as suggested by Toffler over a decade ago (Demsey & Hathaway, 1979:28), Figure 2 identifies some of the components that might be considered in planning individualized educational programs. It must also be stressed that individualized instruction is not so much a pedagogical problem as it is a management and administration problem. Teachers don't need to be sold on the merits of individualized instruction, they need to be provided with the classroom and curriculum management tools to do the job.

It is also important to note that individualized instruction as defined herein provides students with choice -- it does not mean that students are necessarily isolated and confined to work individually. Indeed, students seem to prefer to work at their own pace but in company with a small group of other students who are working at the same pace.

Inability to Use New Technologies

Teachers are not prepared to exploit the full potential of technology.

Gardner (1988) observes that, "... we are into the 'invisible computer' stage. Rapidly, computers are becoming a tool and with a decreasing emphasis on computers as a subject. This invisible intrusion of computers into every aspect of society hasn't yet penetrated to the foundations of education." A major stumbling block, of course, is the unpreparedness of educators (through no real fault of their own) fully to use even the basic potentials of computers much less the more sophisticated tools such as artificial intelligence, interactive computer/laser disc configurations, or interactive satellite communications, for example. Nor do the contemporary classroom staffing and management patterns allow teachers the time that is necessary for developing these alternatives. The impact on public education, of this inability to plan for and use technology, may take the form of private sector intrusion into the traditional domain of public education.

The probability is low that teacher preparation programs will be available to train teachers to use technology appropriately. A review of three treatises on teacher education and the preparation of teachers for the 21st century failed to identify technology as a significant issue or factor needing priority attention (Carnegie Forum on Education and the Economy, 1986; Hrynyk, 1987; Bell, 1988).

High Touch

High Tech
High Touch

Naisbitt (1982: 35) argues that to the extent that technology is adopted to provide for individualization in education, there must also be a counterbalancing high-touch mode (i.e., technologically-enhanced systems designed to help students meet their individual educational needs should do so without isolating students and separating them from necessary and satisfying interaction with others). Renfro (1982: 43-48) supports this view by reporting that the human need for social contacts are frequently unmet in the confines of one's home office. In all probability there is some ideal state of balance between high tech and high touch -- between individual needs and social needs.

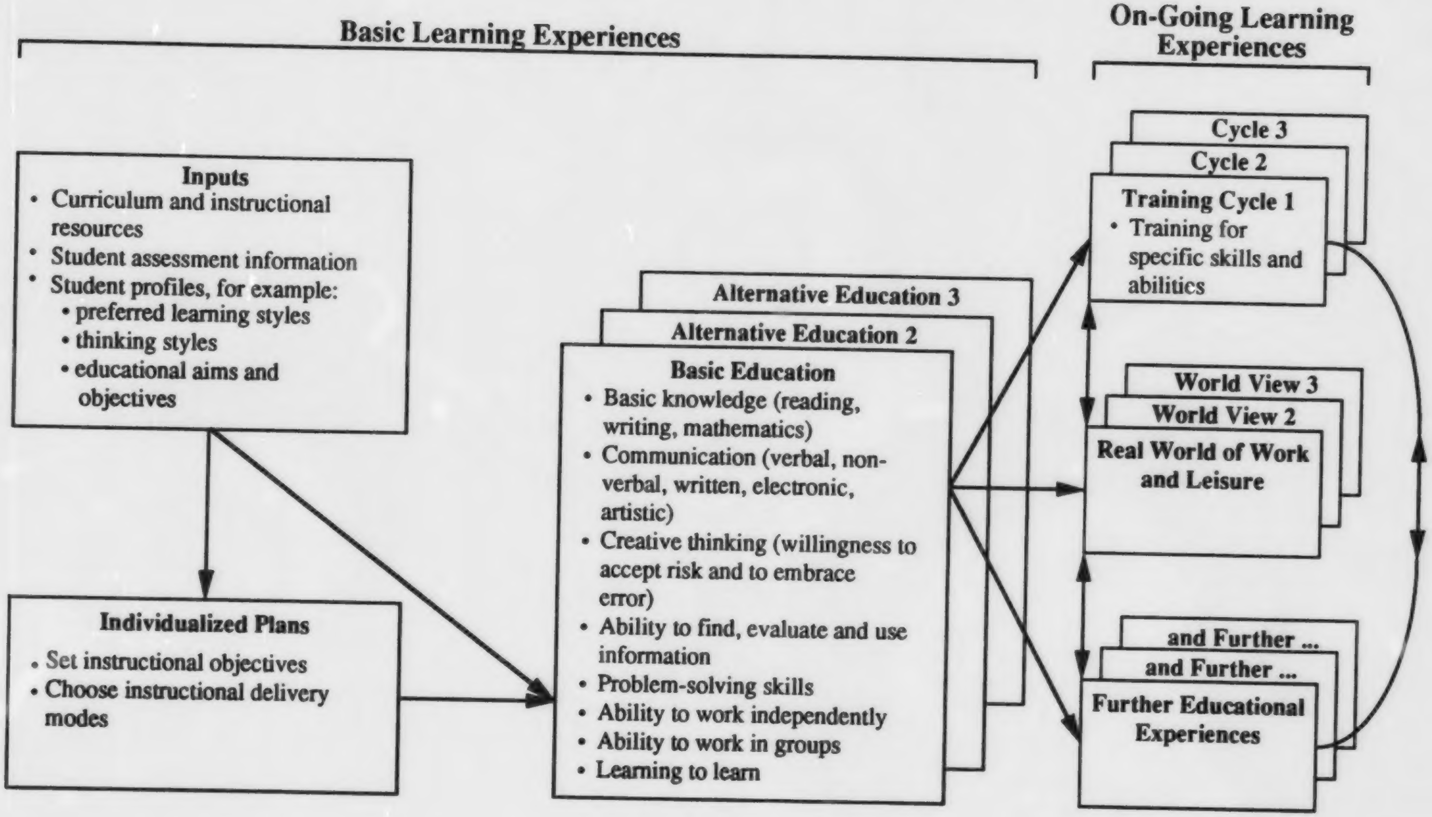

Basic Learning Experiences
On-Going Learning Experiences
Inputs
• Curriculum and instructional resources
• Student assessment information
• Student profiles, for example:
• preferred learning styles
• thinking styles
• educational aims and objectives
Individualized Plans
• Set instructional objectives
• Choose instructional delivery modes
Alternative Education 3
Alternative Education 2
Basic Education
• Basic knowledge (reading, writing, mathematics)
• Communication (verbal, non-verbal, written, electronic, artistic)
• Creative thinking (willingness to accept risk and to embrace error)
• Ability to find, evaluate and use information
• Problem-solving skills
• Ability to work independently
• Ability to work in groups
• Learning to learn
Cycle 3
Cycle 2
Training Cycle 1
• Training for specific skills and abilitics
World View 3
World View 2
Real World of Work and Leisure
and Further ...
and Further ...
Further Educational Experiences

Figure 2. Components of an individualized life-long learning system: A framework for planning an educational pilgrimage.

Shrinking Education Support Base

"Grey power" is increasing and reducing the financial base of support for education.

An analysis of population statistics points to an aging population and a low birthrate. Cetron (1985: 44) concludes that the over-60 age group in the United States will grow from 13 percent of the total population in 1960 to 17 percent in the year 2000. Paralleling this trend is the declining U.S. birthrate which has dropped from 23.7 births per thousand of population in 1960 to 15.5 in 1983. Canadian statistics are more extreme: the birthrates have fallen from 26.8 births per thousand in the population in 1960 to 15.0 in 1983. This means that in the future the percentage of the population with children in school will be smaller than the percentage without children in school. That being the case, it is easy to imagine that for those people without children in school, education may become a lower priority. If that proves to be the case, education may have to compete even more vigorously for tax support in the future than has been the case in the past. Moreover, "grey power" (organized senior citizens) is on the increase.

Grey power increases as the overall population ages. The Canadian government ran into the full force of this power when it recently tried to de-index or reduce the overall old age security benefits. In the end the Government had to withdraw its plans. Not only are the seniors growing in numbers, they also have a number of attributes or characteristics working in their favor when it comes to exercising political clout. Consider, for example, they have an abundance of free time for cooperative activities like lobbying, they are articulate, they have the intellectual and financial resources necessary to make their lobbying effective, and they are still held by the public in the same high regard as the flag, motherhood and apple pie.

Highly Skilled Workforce

A highly skilled workforce needs education. The jobless need new ways for deriving a sense of self-worth.

The post-industrial, high information, high technology society will probably be characterized by a highly skilled workforce. There may be a concurrent shrinking of the blue collar and white collar sectors, largely as the results of the use of robotics (Albus, 1983: 22-27; Coates, 1983: 28-32; & Best, 1984: 61-66). Remaining will be the lower quality jobs, the highly individualized and complex jobs, and the jobs included in the service sector. This shift in the composition of the labor force poses a problem. Not everyone will have the abilities to pursue the skilled jobs and not everyone will want the jobs open to the unskilled. What will these jobless people do? Albus (1984: 38-40) suggests that some may earn their livelihood by owning and leasing robots.

Structural Unemployment

Wages may no longer serve to fairly distribute societal wealth.

Naisbitt (1982: 68-70) makes the point that we are in the throes of a societal restructuring -- a collapsing of the industrial structures and an emergence of the post-industrial (information) structures. Observers seem to believe that the emerging society will not need, or be able to accommodate, as many blue and white collared workers as was the case in the industrial society. They further contend that the relatively high unemployment we see today may be more an already-occurring artifact of societal restructuring than it is an artifact of the state of the economy. To the extent that their perceptions are correct, educational institutions may have to help people find meaning for their lives from something other than work -- presently the most significant source of meaning and self worth for industrial man. Moreover, society may now also need some new mechanisms for distributing wealth. Because of the high rates of unemployment, wages may no longer be suitable for performing this function.

Extended Out-of-School Care

The need for out-of-school care may grow to include hotels for children whose parents work nights.

As the number of single parents increases along with the number of women in the workforce, there will be an increased need for day care services and for out-of-school care services for children of school age. Because people will have more free time in the future, and this increased free time will likely raise the demand for additional services, many of the new jobs in the future may be in the service sector and may extend well beyond the traditionally accepted range of working hours (i.e., nine to five, five days a week) (Cetron, 1984: 429 & Rich, 1984: 43). As a result, the demand for child care or out-of-school care services may extend to 24 hours per day, seven days a week. Hotels for children (maybe even subsidized) may be a possibility. A move in this direction was taken in Ontario where the legislature declared that every new school will contain out-of-school care facilities (Hickl-Szabo, 1987).

At the same time, observations of the current educational scene seem to suggest that the custodial role of schools is a role that teachers would like to see eliminated. Many teachers regard the supervisory activities of custodial care to be non-professional and better provided by others.

Partnerships

Partnerships involve getting the community into the school and the school into the community.

Students graduating from high school today (at about 18 years of age) have spent less than nine percent of their lifetime in school and more than 90 percent of their time has been spent in the presence of influences other than school. Schools clearly have a number of partners when it comes to developing a child to his or her full potential. Because schools can't be all things to all people, these partnerships are going to be more important in the future than they have been up to now. To make these partnerships work, however, there must be suitable coordination and leadership functions provided and educators may be in the best positions to provide them.

Roles of Schools

Roles of schools:
- *education*
- *socialization*
- *ranking and sorting*
- *custodial care.*

When formal schools were first established, and from then well into the 20th century, they provided places for students to learn the skills and abilities required in order for them to fit into the industrial world of work as good responsible citizens. During this period the principal role of schools was to provide a place for children to obtain their education and to become socialized. In some respects schools also serve to sort and select students for different roles in society.

With World War II came the entry of significant numbers of women into the workplace. For those families where both parents were working, schools began to take on a new role -- a custodial role. Schools provided a safe place for children to be while their parents worked. The custodial role of schools is becoming even more apparent today. Playschools, day care centers, kindergartens, and out-of-school care programs all serve to provide opportunities for parents to be free from their children for periods of time each day.

While it is unclear how future changes will alter these multiple roles of schools (education, socialization, ranking and sorting, custodial care), it is important to keep in mind that schools are more than just centers of learning.

Other Forces and Factors

Cetron, et al (1988: 32-34) identify a number of other issues that may influence the shape of education in the future: (a) an expansion of education and training throughout society, (b) new technologies which will greatly facilitate the training process, (c) business taking on a greater role in training and education, (d) a continuing rise in education costs, (e) improved pedagogy, (f) emphasis on development of the whole student, and (g) a reduction in the size of higher education institutions.

Summary

This chapter has served to identify and describe a number of forces and factors (issues) which are believed to have the potential for shaping the way education evolves in the future. The list is lengthy and includes such as issues as: changing goals of education, curriculum content, societal values, life-long learning, individualization of learning, inability to use technology appropriately, need for high touch environments, shrinking educational support bases, need for a highly skilled workforce, structural unemployment, extended out-of-school care, partnerships, and changing roles of schools. The next chapter is devoted to an analysis of the scenarios identified in Chapter 2 in terms of these forces and factors.

Chapter 4

An Analysis of Forces and Factors Influencing Images of the Future

A number of forces, factors and issues capable of influencing education in the future were identified in Chapter 3. The effects of these forces and factors on education can be made clearer by examining them through a lens such as that offered by Lewin's Force Field Analysis techniques (Owens, 1981: 259-264). Through a medium such as Force Field Analysis it is possible to look first at the educational status quo (Figure 3) and then at each of the scenarios outlined in Chapter 2 with a view to gaining a better understanding of the nature and direction of the influences on education (both the restraining and the driving forces) and the relationships among these influences and factors. The relative strength of each of the forces is reflected in the size of print in Figures 3 to 6. The most important forces and factors are at the top of each column and in bold-faced print.

Different scenarios provide different views of the world -- some are more preferable than others.

The scenarios developed in Chapter 2 (projected and possible images of the future of education) are analyzed in Figures 4, 5 and 6. Certainly, it could never be argued that the scenarios are planned or preferred. Neither should anyone argue that projected images of the possible future of education are highly reliable. The trends that have brought us to the point where we are today may shift significantly in the future. Moreover, some unexpected events in the future could markedly and unpredictably shift trends. Some examples of unanticipated past events that have altered the course of history include: the bombing of Pearl Harbor, the energy crisis of the 1970s, major discoveries like the transistor and oil in the Arctic, the assassination of John F. Kennedy, the explosion of the spaceship Challenger, and the Chernobyl disaster. Finally, some social changes come about through something akin to crystallization -- today things are as they always were, tomorrow a whole new set of structures will have fallen into place. This process is nurtured by the quiet networking of people until something like a "critical mass" occurs.

**Activity
Level**

(High Activity Level)

Driving Forces --------->	**<-------- Restraining Forces**
Technology	**Vested Interest of Teachers**
Demands for Accountability	**Inability to Use Technology**
Competition	**Costs of Educational Change**
Educational Role of schools	**Lack of Competition**
Industrial Models	**Educational System Inertia**
Curriculum	
Socialization Role of Schools	
Life-long Learning	
Societal Values	
Cultural Pluralism	
Economic and Political Instability	
Goals of Education	
High Touch	
Highly Skilled Workforce	
Individualization of Learning	
Integration	
Shrinking Support Base	
Transformation of Knowledge	
Extended Out-of School Care	
Partnerships	
Structural Unemployment	

(Low Activity Level)

Figure 3. Analysis of forces and factors influencing education today.

The Superindustrial Scenario

The "Impetus Range" watershed.

The Superindustrial Scenario is based on projections of three trends into the future: technology, industrial models, and competitive forces -- the forces flowing from the watershed of the "Impetus Range".

If one were to weigh the strongest and weakest sets of factors and influences as described in the analysis shown in Figure 4, the result would point to this scenario as being somewhat problematic. The dominant driving and restraining forces are almost equal with the effect that they tend to cancel each other.

And this is in spite of the fact that many of the factors that are already present and at work in the educational area: knowledge is equated with power; communications and computer technology have progressed to the point where interactive television could be made accessible to the vast majority of the population, schools are seen as fitting into a large information network (local area networks, wide area networks, education networks) (Quick, Flashman & Gibeau, 1984: 20-33); computers are used for assisting learning, managing learning, managing resources, and administration; learning systems are becoming franchised; costs of education in the traditional mode are outstripping gains in educational outcomes; and we are coming to accept major technological interventions into society (Communications Era Task Force, 1984: 6). (Consider, for example, test tube babies, genetic engineering, genetic counselling, abortions on demand for any reason -- in effect "designer children".) A trend which is now emerging that would further support the Superindustrial Scenario is the renewed concept of cottage industries, but this time they are information-related industries such as word processing, software development, and so forth. Daily drives to and from the office are being replaced by telephone calls or computer-to-computer hook-ups (Eder, 1983: 30-34).

The major opposing pressures or forces identified in Figure 4 are principally those of institutionalized education. Teachers may be expected to resist the development of any sort of technologically-based educational system that might be perceived as undermining their job security. A second inhibiting factor is the need for individuals to be in contact with each other -- technological systems are perceived to be lacking in a capability for accommodating the "high touch" dimension. Thirdly, the front-end development costs associated with the Superindustrial Scenario are high. Fourth, there is no one or no agency with the authority or the will to examine the factors of the educational production equation and to recommend changes in the mix (i.e., land labor, capital, and information).

The Authoritarian (Economic) Scenario

The "Repercussion Range" watershed.

The Authoritarian Scenario (Figure 5) is based on a projection into the future of the shorter-term accountability and economic/political instability trends which flow from the "Repercussion Range".

The Authoritarian Scenario is founded on the supposition that the depicted driving forces will become the dominant forces as the future unfolds. That being the case, the array of driving forces may be large enough to lend credibility to this scenario. The economy is undergoing a shaking and the effects are being felt world-wide: banks are unstable, the stock markets around the world are in turmoil, unemployment is high and not responding to the normal market and economic stimuli, resources are becoming more scarce, debates are

Activity Level

Driving Forces -------->	<-------- **Restraining Forces**
(High Activity Level)	
Technology	**Vested Interests of Teachers**
Competition	**Costs of Educational Change**
Industrial Models	**Inability to Use Technologies**
Individualization of Learning	**High Touch**
Educational Role of schools	**Educational System Inertia**
Demands for Accountability	**Lack Of Competition**
Economic and Political Instability	Cultural Pluralism
Goals of Education	Societal Values
Curriculum	
Highly Skilled Workforce	
Integration	
Shrinking Support Base	
Socialization Role of Schools	
Transformation of Knowledge	
Extended Out-of School Care	
Life-long Learning	
Partnerships	
Structural Unemployment	
(Low Activity Level)	

Figure 4. Analysis of forces and factors associated with the Superindustrial Scenario.

Activity Level

Driving Forces --------->	**<--------- Restraining Forces**
(High Activity Level)	
Demands for Accountability	**Educational System Inertia**
Shrinking Support Base	**Vested Interest of Teachers**
Economic/Political Instability	**Inability to Use Technologies**
Competition	**Costs of Educational Change**
Educational Role of schools	**Lack of Competition**
Highly Skilled Workforce	Curriculum
Industrial Models	Cultural Pluralism
Socialization Role of Schools	High Touch
Individualization of Learning	
Integration	
Technology	
Extended Out-of School Care	
Goals of Education	
Life-long Learning	
Partnerships	
Societal Values	
Structural Unemployment	
Transformation of Knowledge	
(Low Activity Level)	

Figure 5. Analysis of forces and factors associated with the Authoritarian Scenario.

raging on the issues of declining educational standards, educational costs are under scrutiny, accountability is becoming a buzz word, data banks are growing and they are including more and more personal information -- information that could ultimately be used to judge the societal worth of an individual. As the economic instability escalates, political interventions increase. These factors clearly suggest an environment conducive to authoritarian control -- someone taking charge and setting things back on course. In that sense it is a "political" model -- it is based on the belief that strong government can bring about stability. Education also has some new expectations placed on it -- expectations that it will produce entrepreneurs, risk-takers, people who can take control.

Countervailing forces might be concerns about the invasion of privacy of information and concerns that educational outcomes cannot be easily dealt within the framework of cost-benefit models.

The Ecological Scenario

The "Reverberation Range" watershed.

The basis of the Ecological Scenario lies in a projection into the future of the relatively recent cultural pluralism, integration and knowledge transformation trends flowing from the "Reverberation Range".

A still different set or alliance of factors and issues has been identified (Figure 6) which could form a dominant force in the future thus giving rise to what might be called the Ecological Scenario. In this scenario people are important. Attention would be paid to individual differences (cultural, ethnic, language, religion, geography, learning styles, and personal aspirations). Recognizing that there may not be enough work to go around, the faltering work ethic may be replaced with another base for the derivation of meaning to life and self-concept. The significant role that knowledge plays in society is also producing pressure for educational change.

Working against the pressure to advance the Ecological Scenario in the future are such factors as those that drive the Superindustrial Scenario as well as concerns about educational efficiency and the traditional set of values pertaining to work and delayed gratification. While the Ecological Scenario may describe a possible future, it does not portray education as being terribly cost-effective or efficient.

The Crisis or Collapse Scenario

Cracks in the dam of the "Educational Status Quo".

The fourth scenario -- the Crisis or Collapse Scenario -- is only mentioned in passing and is not analyzed in the same way as the other scenarios.

However, if the strong driving forces of technology, the extent of change required in the content and delivery of education, declining educational outputs, and spiralling educational costs are set against the restraining forces of educational system (institutional) inertia, a human resource complement that lacks an understanding of how to use technology to advantage, and the relatively high front-end costs of educational change, the question that comes to mind is this, Can the emergence of the Crisis or Collapse Scenario be held in abeyance until another, more preferable, scenario can unfold?

Activity Level

Driving Forces --------->	**<--------- Restraining Forces**
(High Activity Level)	
Cultural Pluralism	**Competition**
High Touch	**Industrial Models**
Integration	**Technology**
Socialization Role of Schools	
Transformation of Knowledge	
Educational System Inertia	
Costs of Educational Change	
Curriculum	
Educational role of schools	
Extended Out-of School Care	
Goals of Education	
Inability to Use Technologies	
Individualization of Learning	
Partnerships	
Societal Values	
Vested Interests of Teachers	
Demands for Accountability	
Economic and Political Instability	
Highly Skilled Workforce	
Lack of Competition	
Life-long Learning	
Shrinking Support Base	
Structural Unemployment	
(Low Activity Level)	

Figure 6. Analysis of forces and factors associated with the Ecological Scenario.

A Choice of Futures

What is the preferred future?

It is not apparent that any one of the scenarios discussed so far is clearly the more probable image of the future -- each is possible. There are signs to suggest that many of the factors required to advance any one of the scenarios are already present in society. Because each of these scenarios has significant implications for education, it is useful to summarize the strengths and weaknesses of each scenario and to examine some of the possible implications of each.

The Superindustrial Scenario and the Authoritarian Scenario, as presently understood by most educators, appear to lack a warm and human dynamic. This may give individuals an even greater sense of lack of control in their lives (anomie). Any resulting alienation may be reflected in an increase in incidences of rebellion and violation of basic social codes -- increases in anti-social behavior. The Ecological Scenario, would on the other hand, work to counter this trend. Accordingly, for this reason, and because it is most compatible with the interests of educational institutions and teachers, aspects of the Ecological Scenario may be expected in the future. Nevertheless, many elements of the other scenarios will also be incorporated into education in the future.

For most educators, their time out of university exceeds the present half-life of knowledge --many may be using obsolete ideas.

The public schools system may be in decline (if one looks only at the declining SAT scores and the increase in the number of private schools). Further decline of public schools may be hastened by the entry of the private sector into the educational arena with franchised learning systems or educational delivery systems. While technology has the potential for linking children in front of their living room TV sets with some of the best educators and educational experiences in the world, the useful half-life of an education is five years and the average experience level of teachers is ten to twelve years. It would appear that many teachers may be using a somewhat obsolete set of educational theories and knowledge bases, and for that reason, schools may not be able to change fast enough to utilize technology fully or to withstand the mounting pressure for educational change.

Societal survival in the future may be contingent on new specifications of literacy and new sets of basic knowledge. Creativity, individual initiative, enterprise and the ability to acquire and utilize information may become the new basics of education.

"Grey power" will continue to increase as the overall population ages. This coupled with the declining birthrates suggests that the support base for public education may decline in the future.

Finally, Henchey (1986b: 21) advocates the concept of a learning society. He argues that:

> *The integrated and extended learning services of the present and future demand new management styles, new priorities of leadership, and more effective and widespread participation in decision-making. We need to reconsider the leadership role of governments at all levels; the relative rights and responsibilities of different partners in learning, that is, elected officials, civil servants, administrators, teachers, parents and students, as well as special interest groups; and the boundaries*

> *between matters of public decision and matters of the professional competence of teachers.*

Faced with the prospect of developing learning systems to support such a learning society, Perelman (1987: 13) offers some important thoughts:

> *The development and application of ever more productive technology for teaching and learning is growing everywhere outside of public education: in industry, in the military, in the private sector of education and training, and in the home. There is no way the public education system can prevent the application of advanced learning systems -- except within the schools.*
>
> *Technical innovation, to be sustained and effective, cannot be treated simply as an 'add-on' to the established curriculum and process of schooling. Rather successful innovation will require fundamental transformation of the entire education system.*
>
> *In practice this means that changes in technical systems -- for instance, educational applications of computers, video discs, robots, cable and satellite communications, and software, as well as new drugs, nutritional practices, architectural designs , or learning methodologies -- are inextricably connected to the other major components of the schooling system: human resources, management, and organization.*
>
> *The situation is unprecedented, and presents major challenges to educational policy and planning. Public schools that embrace the technological transformation of teaching will be invaluable assets in the fight for national competitiveness; those that resist change risk following the downhill path blazed by America's giant steel companies.*

A Composite Scenario

A vision of education in the future is made clearer by knowing what it is that is to be achieved.

Having come this far, it is somewhat easier to develop an image of the future which is perhaps more plausible than any of the scenarios considered thus far, a scenario, or vision, of the future which could be useful as a guide in future planning of education. This more plausible scenario is the Composite Scenario -- a scenario based on the best of each of the other scenarios. Figure 7 depicts the Composite Scenario. The pressures of untried and untested educational potentials from all sources that are contained in the reservoir behind the dam might be channeled in such a way as to relieve the pressure on the dam -- the educational status quo. This could occur in three ways: the dam could be bypassed, the dam could be modified or restructured to provide a controlled spillway, or both could occur. However, these choices are critical. If the bypass alternative materialized, it may be as the result of a significant increase in private sector competition in education. On the other hand, restructuring of the dam itself, while costly, may lead to a much enhanced and improved educational system.

It is this reformed educational system that appears to hold the greatest promise for affecting the necessary educational reform but it may also hold one of the greatest challenges that educators will face in the next decade.

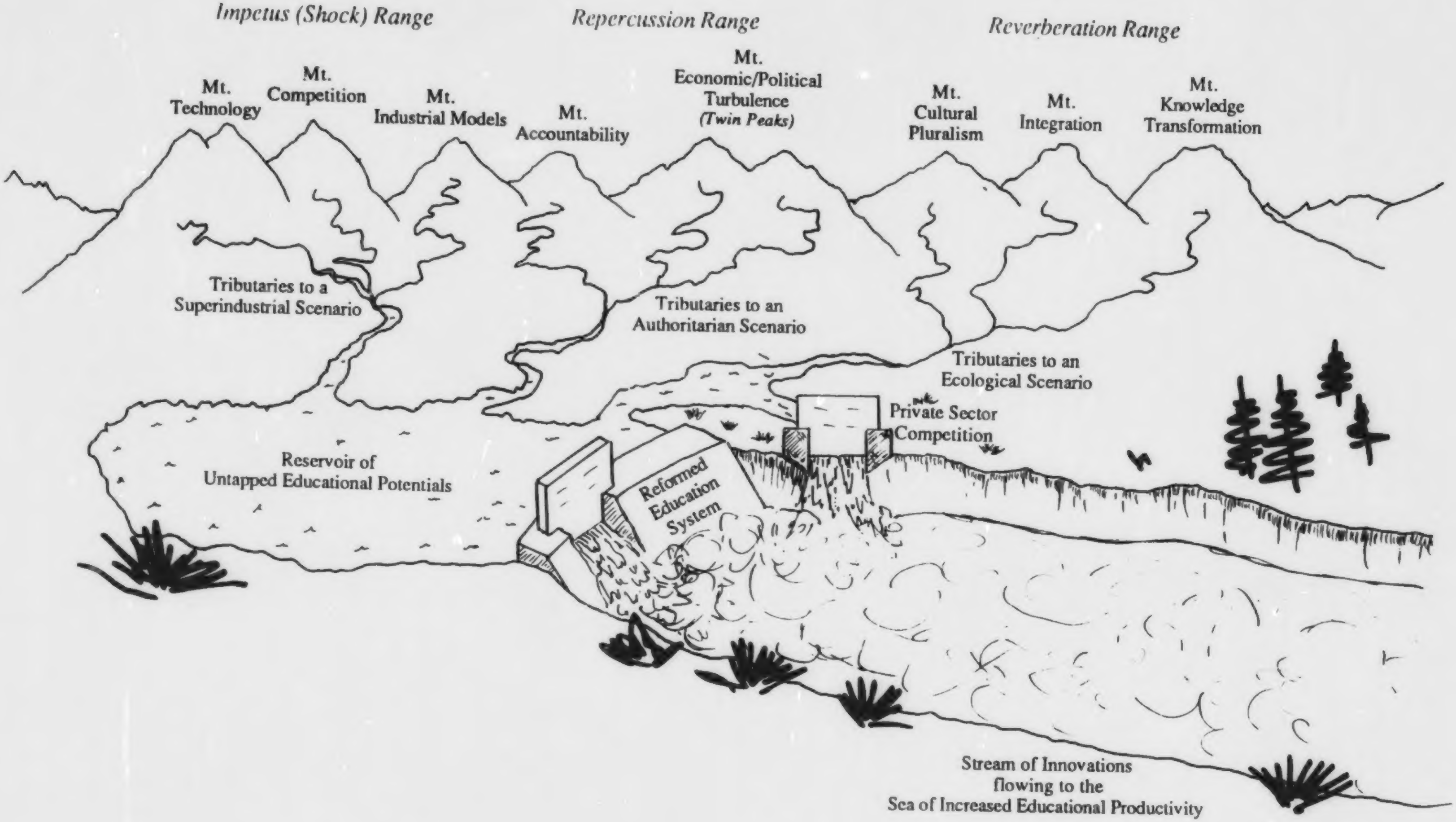

Impetus (Shock) Range
Repercussion Range
Reverberation Range
Mt. Technology
Mt. Competition
Mt. Industrial Models
Mt. Accountability
Mt. Economic/Political Turbulence (Twin Peaks)
Mt. Cultural Pluralism
Mt. Integration
Mt. Knowledge Transformation
Tributaries to a Superindustrial Scenario
Tributaries to an Authoritarian Scenario
Tributaries to an Ecological Scenario
Private Sector Competition
Reservoir of Untapped Educational Potentials
Reformed Education System
Stream of Innovations flowing to the Sea of Increased Educational Productivity

Figure 7. A depiction of forces and factors influencing the Composite Scenario.

An "Educational Reform" Scenario

The Composite Scenario (an educational reform scenario) draws on the strengths of each of the earlier scenarios and integrates them into a meaningful whole. The Superindustrial Scenario provides the technology (hardware, software and human resources) and the efficiencies and capabilities needed to accommodate the required choice -- alternative or competitive educational delivery systems. The pressures driving towards an Authoritarian Scenario are the demands for accountability and cost-effective educational delivery systems and these must be accommodated in the Composite Scenario. The Ecological Scenario provides a sensitivity to issues such as integration -- integration of concepts within a student's understanding, integration of subjects within the curriculum, and integration of planning and people in communities, regions and nations. The effect would be to maximize the use of available human resources.

Through the Composite Scenario it is possible to see education being altered in many desirable ways with the high probability that educational delivery might become more productive and that many more of the individual educational needs of students might be better met in the future than is the case today.

Summary

An analysis of three scenarios (Superindustrial, Authoritarian, and Ecological) found strengths and weaknesses in each. None of the scenarios, when taken alone, appears to have the capability for meeting educational needs in the future, though all have some desirable strengths or attributes. Integrating these strengths into a Composite Scenario provides the basis for a vision of education in the future that is desirable, worthy of pursuit and sufficiently clear to provide some direction for future planning.

The next chapter looks at uses of technology in education today and provides an inventory of the currently available technological resources (i.e., the hardware, software, management and quality control tools) which could be used in a redesigned educational system.

Chapter 5

An Inventory of Available Resources

Technology should be focused on educational problems.

There is an ever-increasing need for clear visions of both education in the future and of the right role of technology in education (i.e., not a vision of the nature of technology in the future, but a vision of how today's technology can be used to solve educational problems both now and in the future), visions which are clear enough to focus educational decision-making today so that the best possible educational future unfolds tomorrow. Necessarily, a vision of the role of technology in education must flow from a broader vision of possible, probable or preferable educational futures -- visions which may be projected, proposed or planned. Toward this end, Chapter 4 describes some of the possible educational scenarios or visions of the future and proposes a Composite Scenario -- a scenario designed to capture the best attributes of each of the other scenarios.

It is the intent of this chapter to describe more completely the way technology is used in education today and to identify potential resources currently available to education.

Technology in Education Today

Technology is more than hardware. It is also information.

Technology in education most often means things, (e.g., computers, video discs, software (i.e. courseware), film projectors, television, video recorders, cassette recorders, and on and on). Every school has closets filled with these things -- most unused or at best inefficiently used. But technology can have a broader meaning. Technology may also mean information -- the information needed to design and use these things (i.e., hardware).

Mecklenburger (1988: 18) cites the NSBA definition of technology which is somewhat broader in scope. To that organization, "Technology includes all manner of video, distance communications, curriculum management systems, administrative networks, and more -- at home and in communities, as well as in school."

Perelman (1987:33) cites a definition of educational technology* "... as the entire technology of education rather than merely as the use of technology in education...."

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* Percival, F. & Ellington, H. (1984). *A Handbook of Educational Technology*. London: Kogan Page.

For the purpose of subsequent discussions, educational technology is defined herein as the applied science of education which includes both the methodologies and the equipment for planning, implementing and evaluating educational programs. Defined in this way, educational technology has at least four components: (a) extant curriculum and instructional theories; (b) communications and information management hardware and software; (c) management sciences including planning frameworks, operations research, quality control mechanisms, and value analysis; and (d) the skilled human resources needed to implement a high technology educational delivery system.

The general consensus across North America appears to be that technology (and especially computers) is not very effectively and efficiently used by educators and perhaps this is the case for two reasons: there is a substantial resistance to change, and there is a lack of understanding of how to use the new technologies.

New technologies are not well used in education.

This lack of understanding of the new technologies can be best exemplified by looking at the more common patterns of use for the growing numbers of computers in classrooms across the country. Reports indicate that there are some areas where the computer-to-pupils ratios are as high as one computer for each 14 students although the average is probably closer to one computer for each 40 students (Reinhold, 1986:28). Rather than using the technological tools as substitutes for labor (or any other of the factors of production) technology (and especially computers) is most frequently used:

As teaching machines, computers have had little impact.

- As a substitute for the teacher in dull and routine activities such as tutorials and drill and practice exercises. (Most of the current research suggest that computer-based instruction is no better and no more efficient than instruction received from a good teacher. "As a teaching machine it [the computer] has little -- if any -- impact" (QED, 1987: 8). Levin, et al (1987: 70) conclude that on the basis of their findings "... educators should question unqualified assertions that CAI (computer assisted instruction) is a more cost-effective intervention than other alternatives" (e.g., peer or adult tutoring). With respect to the arguments for using technological tools as a substitute for labor in the educational production equation, Shavelson and Winkler (1982: 1) find the arguments to be misleading.

> *First, most cost analyses focus on hardware costs: these costs are not the major factor driving the costs of computer assisted instruction (CAI). Second, technology is more likely to change the skill mix of labor in education than to decrease the intensity of labor. Third, studies of effectiveness of CAI lead to a policy of integrating the computer with the teacher, not replacing the teacher. And fourth, the cost of replacing a significant portion of teacher time with CAI is currently prohibitive.*

Unhappily, the cost of software to enable computers to act as teaching machines is high and that software is most often curriculum specific and therefore not generalizable to other areas of the curriculum. Instructional management software is more generalizable but extremely scarce.

- In Telidon applications as an electronic page-turner.

- To manage banks of test items (in those few cases where they exist).

- As word processors in some writing classes.

- As a word processor, spread sheet or data base in Business Education classes.

Too much time is spent talking about computers and too little time about how to use them.

- In computer literacy courses. In most of these courses the emphasis is on how the computer works and how it can be programmed. Little attention is given to encouraging students to think about how it can be used as a tool to solve problems or to change the way we normally do things.

- As a reward system -- students are allowed to use computers to play video games after other work has been successfully completed.

The educational use of technology needs to be redirected.

The educational uses of technology, and especially computers, should be redirected in order to obtain a great benefit. For example, software applications could be developed in those areas which are highly generalizable. One need is for improved instructional management tools in support of individualized or independent learning. Such software would have to be generalizable to any curriculum and in any setting. The Program Evaluation Review Technique or PERT (a project management tool which is applicable to virtually any project) so widely used in project management in the private sector represents the sort of generalizable software that could be adopted into education.

Available Technological Systems

Aside from presently available curriculum and instructional theories and skilled human resources, there is a wide range of other technologies and management sciences also available, which when taken together constitute educational technology.

On the technical side, there are many applicable technologies, peripherals, storage media, and communication channels presently available. Some of these technologies are well established while others are emergent and their full development may be subject to a great many, as yet unseen, variables.

Basic technologies. Among the widely used technologies are computers (mainframes, minicomputers and personal or microcomputers), telephones, television, radio, and recording devices (disks, tapes, compact disks). Holographic technology represents one of the newer technologies that may find wide application in the future.

Peripherals. Peripherals represent those devices that may be connected to the basic technologies in order to increase diversity in applications. Peripherals include facsimile machines, printers, modems, optical readers, voice synthesizers, speech recognition devices, smart cards (i.e., bank cards), copiers, and plotters.

***Storage media*.** Information may be stored in print and microfiche forms and in many electronic (analog or digital) forms. The latter includes audio tape, video tape, audio disks, video disks, compact disks, floppy disks, hard drives, and holograms. All of these devices (except audio and video disks and holograms) offer multiple read and write capabilities.

***Communications formats*.** Communications (i.e., transfer or exchange of information between two points) may take place by using a number of devices or technologies. For example, communications may take place: through face to face exchange between two or more people; via surface or air mail; point-to-point by means of wires, coaxial cables, optical fiber cables, and by means of microwave transmissions -- wide-area broadcasting (radio, television) and satellites.

The use of these technologies, and most especially computers, may need to be redirected in order to obtain a greater educational benefit. For example, software applications could be developed in those areas of need which are highly generalizable. One need is for improved instructional management tools in support of individualized or independent learning. Ideally, such software should be generalizable to any curriculum and in any setting.

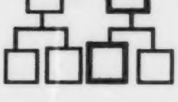
Some Management Science Tools with a Potential for Education

Management science tools have never been fully exploited in education. Coupled with other forms of technology, they make individualized instruction feasible.

Having examined some of the problems confronting education today, it is now possible to consider the challenges to be met through a restructured education system and delivered through a technology-enhanced learning system. And a number of management sciences and technological resources are available for use in this process. Many of these tools were developed in the 1960s and 1970s. Nevertheless, it is believed that their use was never fully exploited. Accordingly, they will be introduced briefly and their applicability to education discussed in a general way in this chapter and with more detailed applications discussed in later chapters. Among the management tools to be discussed are: (a) flow-charting, (b) networking, (c) operations research, (d) reliability and quality control, (e) human factors analysis or ergonomics, (f) value analysis, and (g) planning and evaluation systems.

Flow-charting

Flow-charting is a means of graphically describing the interrelatedness of a set of components, activities or tasks. Typically, flow charts focus on such things as authority, work flow, functions, information flow, or product flow.



A flow chart focussing on the authority structure within an organization results in the conventional organizational chart with which we are all familiar. Workflow charts break out, or identify, the specific steps or sequences of steps in a task. Flowcharts which reflect the steps in development or completion of a product are referred to as product or process flow charts. Workflow and product flow-charts may be combined to reveal the through-put processes and patterns of an organization. Function flowcharts are similar to workflow charts: they describe the functional activities of people. In many instances functions may be regarded as being synonymous with roles. Information flowcharts describe how information flows within an organization. These charts often indicate when decisions are required and how the decisions are to be made.

Network-Based Management Systems

Network-based management systems provide an unique approach to problem solving. Complex long-range goals are repeatedly subdivided into a hierarchy of goals and objectives, and these complex goals become relatively simpler when examined in their constituent parts. A program involving the combined efforts of thousands of employees expended over a period of several years may be broken down into many small tasks, each requiring a few employees over much shorter time intervals. The approach recommended by Miller (1963) and Archibald and Villoria (1967) calls for the subdividing of tasks into discrete events or activities which may be regarded as milestones -- unambiguous indicators of progress. The subdivision of broad goals can be handled in a number of way as illustrated in Figure 8. These activities or events, once identified, are arranged into a network or flow diagram representing a logical approach to the attainment of the chosen long-range goals.

The power of networking methodologies does not lie just in the ability to handle subdivision of large objectives into many small objectives as suggested in Figure 8. Rather, their true power lies in their ability to link and manage the complex interrelationships among objectives at any given level of detail as shown graphically in Figure 9.

Network development also entails estimating the time required to complete each activity or event. An approach for estimating activity duration times is provided which capitalizes on the the fact that those who are directly involved in the planning process have some experience at similar tasks. The estimates of activity times are intended to bracket the expected activity time in a prescribed way with three estimates of activity time being used; the optimistic time, the most likely time, and the most pessimistic time. By using these three estimates in a statistically weighted formula, the manager can calculate the expected activity duration for each network event or activity with a 0.5 probability that the activity or event will be completed on or ahead of schedule. The summation of all activity times in a project gives the expected completion time for that project, again with a probability of 0.5 that the total task will be completed on or ahead of schedule.

The effectiveness of tools such as PERT is a direct function of information. The amount of information necessary for a particular decision-making situation will be proportional to the amount of uncertainty initially surrounding the problem. The greater the uncertainty, the greater will be the amount of information needed to reduce it.

After the networks have been developed for small tasks or projects they must be integrated into a larger network representing a larger or broader

Terminal Goals	Enabling Ojectives (Level 1)	Enabling Objectives (Level 2)
Goal 1	Sub-goal 1.1	Sub-goal 1.1.1 1.1.2 1.1.3
Goal 2	Sub-goal 2.1	Sub-goal 2.1.1 2.1.2 2.1.3
Goal 3	Sub- goal 3.1	Sub-goal 3.1.1 3.1.2

Figure 8a. Identifying enabling objectives nested within terminal goals.

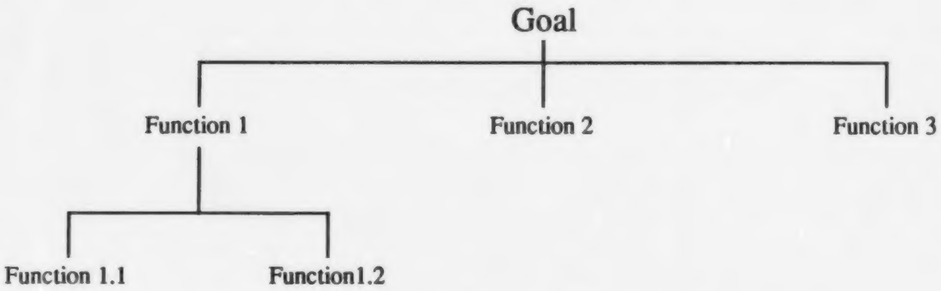

Goal
Function 1
Function 2
Function 3
Function 1.1
Function1.2

Figure 8b. Identifying functions nested within goals.

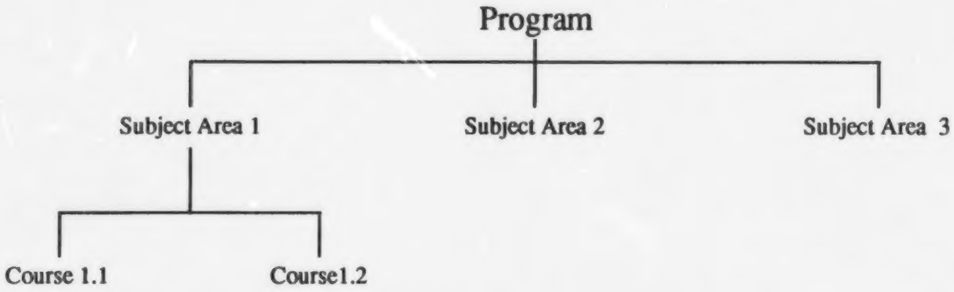

Program
Subject Area 1
Subject Area 2
Subject Area 3
Course 1.1
Course1.2

Figure 8c. Identifying courses nested within programs.

Figure 8. Identification of goals and objectives nested within higher order goals.

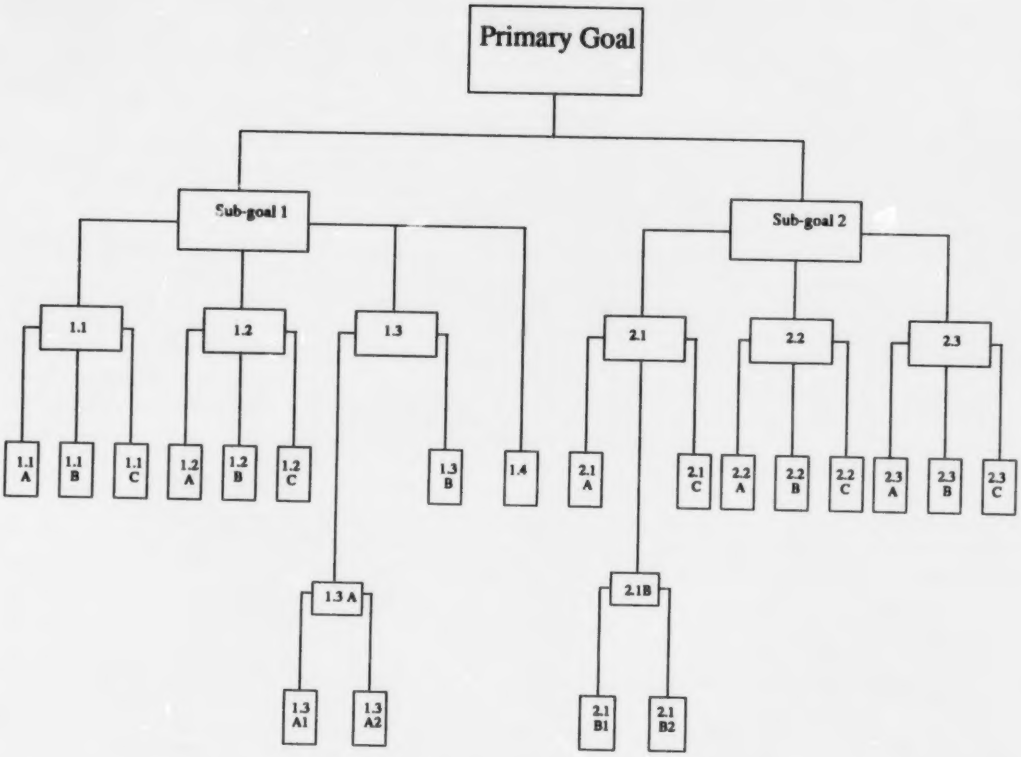

Primary Goal
Sub-goal 1
Sub-goal 2
1.1
1.2
1.3
2.1
2.2
2.3
1.1 A
1.1 B
1.1 C
1.2 A
1.2 B
1.2 C
1.3 B
1.4
2.1 A
2.1 C
2.2 A
2.2 B
2.2 C
2.3 A
2.3 B
2.3 C
1.3 A
2.1B
1.3 A1
1.3 A2
2.1 B1
2.1 B2

Figure 9a. Typical breakdown of objectives. Such a breakdown fails to identify relationships among objectives.

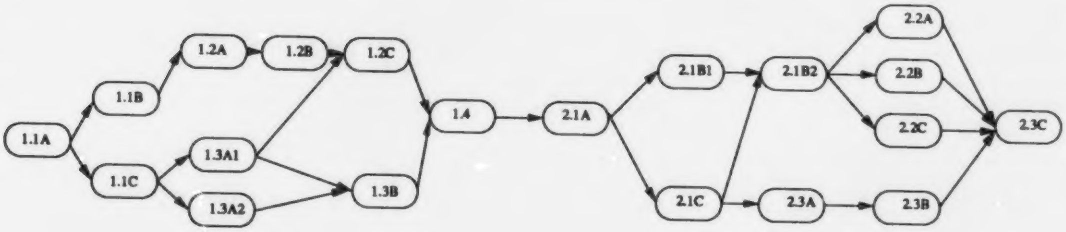

1.1A
1.1B
1.1C
1.2A
1.2B
1.2C
1.3A1
1.3A2
1.3B
1.4
2.1A
2.1B1
2.1B2
2.1C
2.2A
2.2B
2.2C
2.3A
2.3B
2.3C

Figure 9b. Objectives organized into networks to better reflect interrelationships among objectives.

Figure 9. Managing the interrelationships among objectives identified in a Work Breakdown Structure.

plan. Interface areas must be carefully established so that delays and problems are not unnecessarily created. Resolution of the interfaces between and among networks often brings out the bargaining aspects of decision-making.

The last step of network planning entails allocation of resources to each task. These estimates of resource requirements may be aggregated to reflect the total project budget.

Steps in networking:
- *organizing objectives*
- *timing*
- *interfacing*
- *budgeting.*

Once the network of objectives has been organized, timed, interfaced, and resources allocated (if a costing program is to be utilized), the data may be either transferred to a computer format, or if the task is small, handled manually. In either case key events are identified for several levels of summarization so that condensed networks may be presented to management for review. As they are submitted to periodic review, these key events highlight problems for management -- essentially forcing decision-making by exception.

One of the derivatives of the activity-time estimating cycle in the program is an approximation of the standard deviation of the activity time (one-sixth of the difference between the most pessimistic and the most optimistic expected completion times). The standard deviation may be regarded as an uncertainty factor and used to identify events where increased information should be focussed.

PERT is project-oriented. CPM is process-oriented.

A variation of the PERT technique is the Critical Path Method (CPM). In practice the CPM is an activity or job-oriented plan best used on well defined projects or in continuous process operations. Maximum benefit from the CPM approach is realized on projects that are under one organizational unit, free from uncertainties, and centralized.

PERT, which may also be activity oriented, is best applied to large and hard to define programs, programs with large degrees of time and cost uncertainties, and programs with wide geographical distribution and complex logistics.

One further difference hinges on the expenditure of resources. CPM activities may be accelerated by an increased application of resources. PERT activities are more uncertain and increased resource expenditure improves the situation only to a point.

PERT can be used to manage students in individualized programs.

Since the curriculum and the programs followed by students are part of a process, a process which contains a high degree of uncertainty and uniqueness (and most suited to the PERT process), the approach recommended here is to adopt PERT methodologies to a network-based curriculum and to use it as the basis for building a comprehensive learning system. The specific curriculum networking methodology which follows in Part II draws on the strengths of PERT networking strategies. The proposed approach will be shown to be able to accommodate many uncertainties stemming from such variables as: teacher effectiveness, student differences, and the application of different approaches to teaching and learning.

So that the reader can fully appreciate how the network-based approach is to be used in the curriculum development and implementation process, an understanding of the basic networking principles is essential.

Networks are made up of two basic elements: boxes, bubbles or balloons which represent activities and arrows which represent constraints. A segment of a simple network is shown in Figure 10.

In preparing a network representation of a set of tasks, certain conventions must be followed. Arrow heads entering activity cells represent constraints imposed by predecessor activities. Arrow heads leaving an activity represent constraints on successor activities. Successor events cannot begin until all predecessor constraining activities have been completed. Parallel activities may be completed concurrently. With the exception of the start and ending activities, all activities must have both predecessor and successor activities. The initial critique of a completed network configuration is accomplished by ensuring that the network represents an optimal method of executing the intended activity -- it must look logical, (i.e., it must have face validity).

Planning a network begins by defining broad global objectives.

Planning a network-based program may begin as the broad global objectives are defined. The planner's first task is to extract from these delineated objectives, the specific ends to be achieved together with expected completion times and resource costs. With this information at hand a Work Breakdown Structure (Figure 11) is developed. Each task for the Work Breakdown Structure is assigned to an appropriate group in the organization. This unambiguous assignment of tasks allows each individual or group to plan their own work thus eliminating the confusion that occurs when organizational units are unintentionally assigned overlapping responsibilities. This is especially important in curriculum programs where similar or identical objectives may be pursued in a number of different subject areas or at a number of different levels in the curriculum.

Based on the task definitions contained in a Work (Project/Program) Breakdown Structure, each participating group develops a more detailed network to reflect their initial plans for implementing their assigned objectives.

Since the network is also a method of time planning, it is necessary to estimate the duration of each activity in the completed network. While some occasions permit the use of single time estimates or best guesses, the preferred methods use empirically derived statistics or the three-time estimate which is based on a weighted average of the most optimistic estimate of elapsed activity time, the most pessimistic estimate of elapsed time, and the most likely estimate of elapsed time. Time estimating criteria are the following: the most likely time (m) is the time estimated for completion of the activity under normal conditions, the most pessimistic time (b) is the worst time lapse estimated, barring acts of God. The pessimistic time will probably be encountered only once in 100 cases. The most optimistic time (a) is the best possible time and it too has a probability of occurring only once in 100 cases.

An estimate of the expected activity time for each event (t_e) is calculated by means of the following formula:

$$t_e = \frac{a + 4m + b}{6}$$

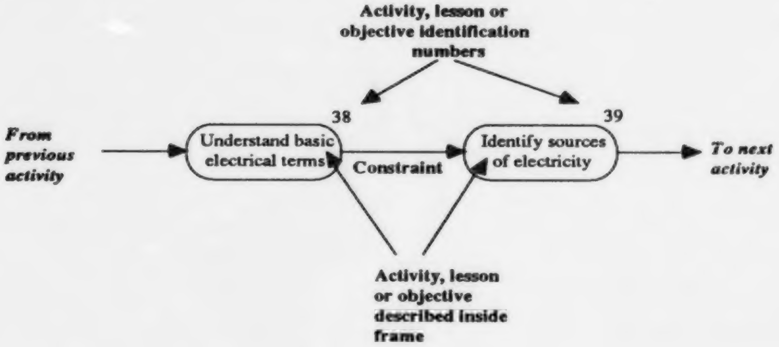

Activity, lesson or objective identification numbers
38
39
From previous activity
Understand basic electrical terms
Constraint
Identify sources of electricity
To next activity
Activity, lesson or objective described inside frame

Figure 10a. Objectives are represented by "bubbles" or "balloons". The relationships among and between objectives are described by arrows. Numbers assigned to the objectives serve as identification codes.

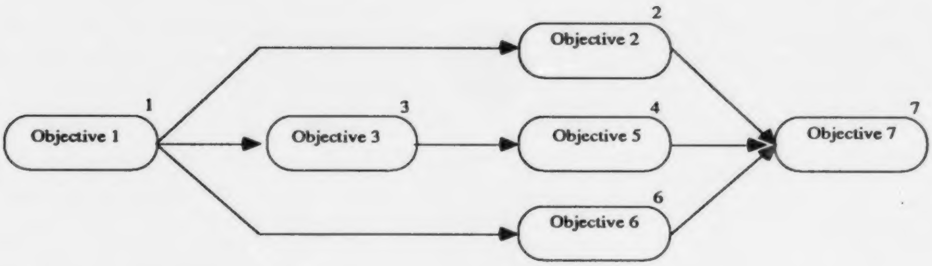

2
Objective 2
1
Objective 1
3
Objective 3
4
Objective 5
7
Objective 7
6
Objective 6

Figure 10b. Once Objective 1 has been completed, Objectives 2, 3 and 6 may be undertaken concurrently. Objective 3 must be completed before beginning Objec tive 5.

Figure 10. Elements of a network.

	Assignment of Responsibility			
Objectives to be achieved	**Dept. A**	**Dept. B**	**Dept. C**	**Dept. D**
Objective 1				
1.1	Yes			
1.2			Yes	
Objective 2				
2.1	Yes			
2.2			Yes	
2.3				Yes
Objective 3		Yes		
Objective 4				
4.1	Yes			
4.2				Yes
4.3		Yes		
Objective 5			Yes	
Objective 6				
6.1	Yes			
6.2				
6.2.1			Yes	
6.2.2		Yes		

Figure 11. Format for developing a Work Breakdown Structure.

Systematically collected information can be used to pinpoint scheduling problems.

Since b - a represents the range of the time estimates, one-sixth of the range represents an approximation of one standard deviation (*sd*). The expected time (t_e) represents the median of the time estimates with one-half of the cases falling above or below the median. While time estimates ordinarily tend to fall into a normal distribution, experience indicates that there is a greater likelihood of activity completion occurring late rather than early. Therefore, the selection of m determines the actual shape of the distribution. In this regard, a balanced estimate of $a = 2$, $m = 5$, $b = 8$ time units is an improbable estimate. It is much more likely that the pessimistic time will deviate more widely from the expected time than will the optimistic time. A more realistic time estimate might turn out to be $a = 4$, $m = 5$, $b = 8$ time units. A rule of thumb suggests that expected activity time for any work package should not exceed approximately five to seven percent of the total network time (i.e., a network for any initiative should contain 15 to 20 or more activities). Tasks or activities that have an excessively-long estimated time for completion may indicate either a lack of information available to the planner or that the tasks are altogether too large and complex and require further subdivision.

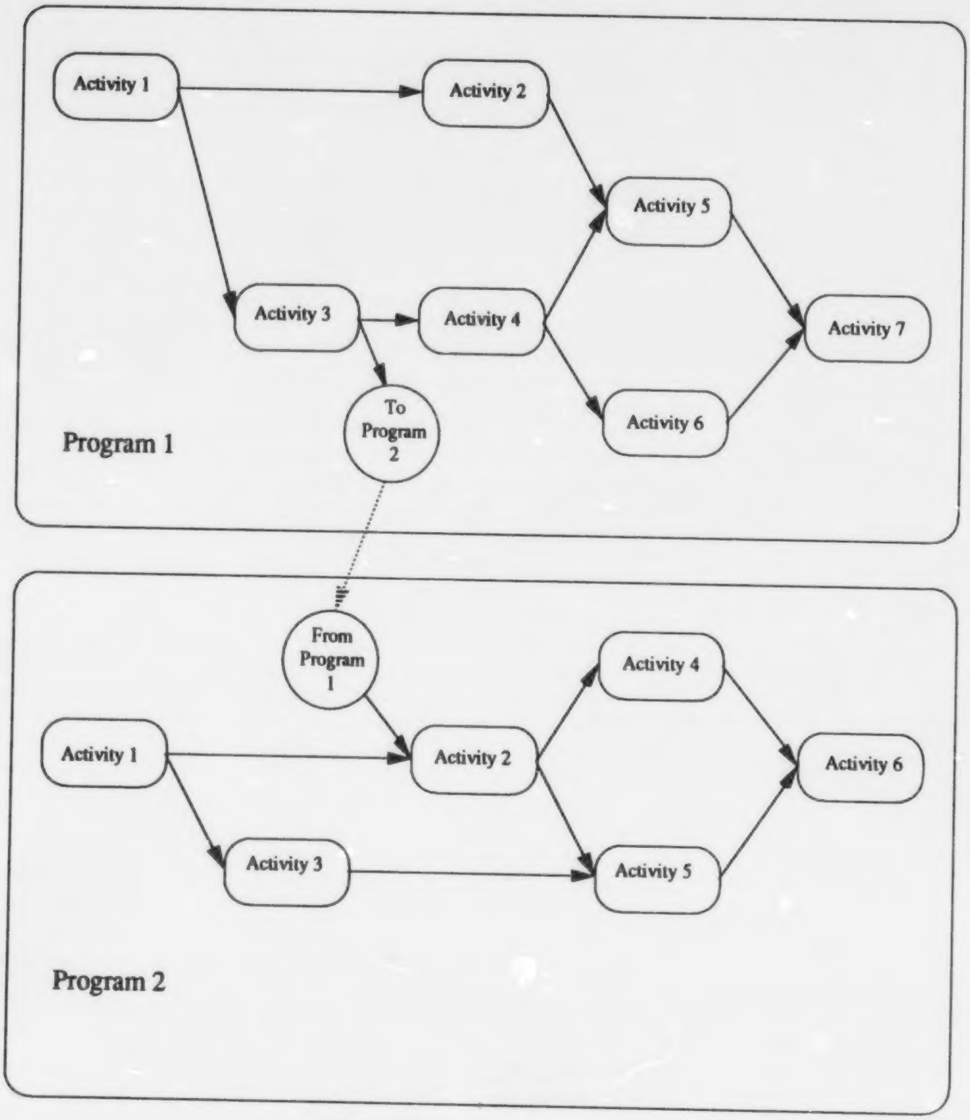
Since the starting and ending events of a network correspond to major milestones, it is important to establish that the total network activity can be accomplished in the period of time allocated. The earliest expected completion time (*TE*) for an event or activity in the a network can be determined by summing the activity times (Σt_es) from the starting event to the ending event. The expected completion time for a project or program (*TE*) should occur on or before the scheduled milestone. The latest allowable date for any event completion (*TL*) can be determined for each event by starting at the ending event and summing t_es forward toward the starting event. The slack time (*TS*) for each activity or event is found by subtracting (*TL*) from (*TE*). The path with the least slack, or the greatest negative slack, is the critical path. This is the path to which the planner must devote the greatest attention when reviewing the program.

Objectives in one program may be linked to objectives in other programs.

It is possible, on programs that are composed of many networks, to find constraints on events imposed by interfaces with other networks. Network validation entails checking the critical paths of each network to make certain the interface events do not unduly delay the program. Figure 12 describes the relatedness of networks in a program. Inasmuch as each network represents the activities of different groups of people, constraints on events indicate areas where the bargaining aspects of decision making are very much in evidence.

Another feature used with the larger PERT programs is network summarization. While each work groups deal with a network containing roughly 15 to 100 events or activities, a program as seen from a senior administrative position could easily include thousands of activities or events -- a figure well beyond the data handling limits of an individual's mind. To reduce the data volume, key events may be identified in each network. On larger programs computers calculate the critical paths of these key events. The result is a vastly simplified, yet extremely accurate, summary network for presentation to senior management.

For programs implementing PERT COST, it follows that the next step is to allocate resources to the activity paths. The costing procedure is similar to the timing methods. Total network costs must be reviewed



Activity 1
Activity 2
Activity 5
Activity 3
Activity 4
Activity 7
To Program 2
Activity 6
Program 1
From Program 1
Activity 4
Activity 1
Activity 2
Activity 6
Activity 3
Activity 5
Program 2

Figure 12. Network validation occurs by linking activities on one network to activities on a second network. In this illustration, Activity 3 in Program 1 constrains Activity 2 in Program 2.

and revised until they too fit within the guidelines prescribed for each objective.

Learning systems should integrate "what to do" functions and "how to do it" functions.

The completed network has a potential for including all of the information and summarization levels identified in Figure 13. As will be seen in Part II, the proposed learning system has capabilities for facilitating both the "what to do" functions and the "how to do it" functions. Indeed, a strength of the learning system will be seen to lie in the latter -- it aids the development of implementation strategies and it facilitates three important evaluation types: the curriculum, students, and teachers.

In practice, progress made towards completing the activities described in the networks may be tracked manually or with the aid of a computer. Manual applications of PERT may be further simplified by using calendarized networks, networks drawn to scale along a linear time base. An example of a Gantt chart converted to a calendarized network is shown in Figure 14. Since the position of the event in the network represents time, slack time may be read directly from the network, a most useful feature in manual applications.

Networks must be updated and progress reviewed on a regular basis, usually weekly. This allows several reviews during the lifespan of each activity, even though the activities occupy only short lengths of time. At the end of each review, exceptions to planned progress are analyzed to determine the impact on the critical paths, and to develop alternatives when the critical paths increase beyond allowable tolerances.

Operations Research

Operations research is simply research on operations -- a quest for logical, systematic and scientific ways of doing things.

An outgrowth of military planning in World War II, operations research is intended to improve the decision-making process through use of mathematical models and techniques. Operations research includes several different approaches or problem-solving strategies: linear programming, queuing theory, game theory, dynamic programming, and simulation. Queuing theory and simulation are highly relevant to learning system design. Queuing theory (or waiting line theory) simplifies the process of deciding how many units of a particular resource are required to serve a specified number of clients. Simulation theory is relevant to the planning of simulations to augment such courses as science, ecology, and so forth.

Linear programming. Linear programming is a mathematical technique wherein the best allocation of limited resources may be determined by manipulation of a series of linear equations.

Queuing theory. Queuing theory is the technique used to determine the most efficient handling of customers awaiting services. It is used to resolve bottlenecks in flow patterns (e.g., How many computers will it take to allow 90 students to each have five minutes of access time during a one-hour period and with a waiting period of no more than five minutes?). The effects of using a number of different equipment levels in solving this problem is illustrated in Figure 15.

In the example shown, a total of ninety students, arriving randomly in five minute intervals, and seeking a five minute period of time at a computer work station, can be handled effectively by eight work stations. Only one student has to wait more than five minutes and the

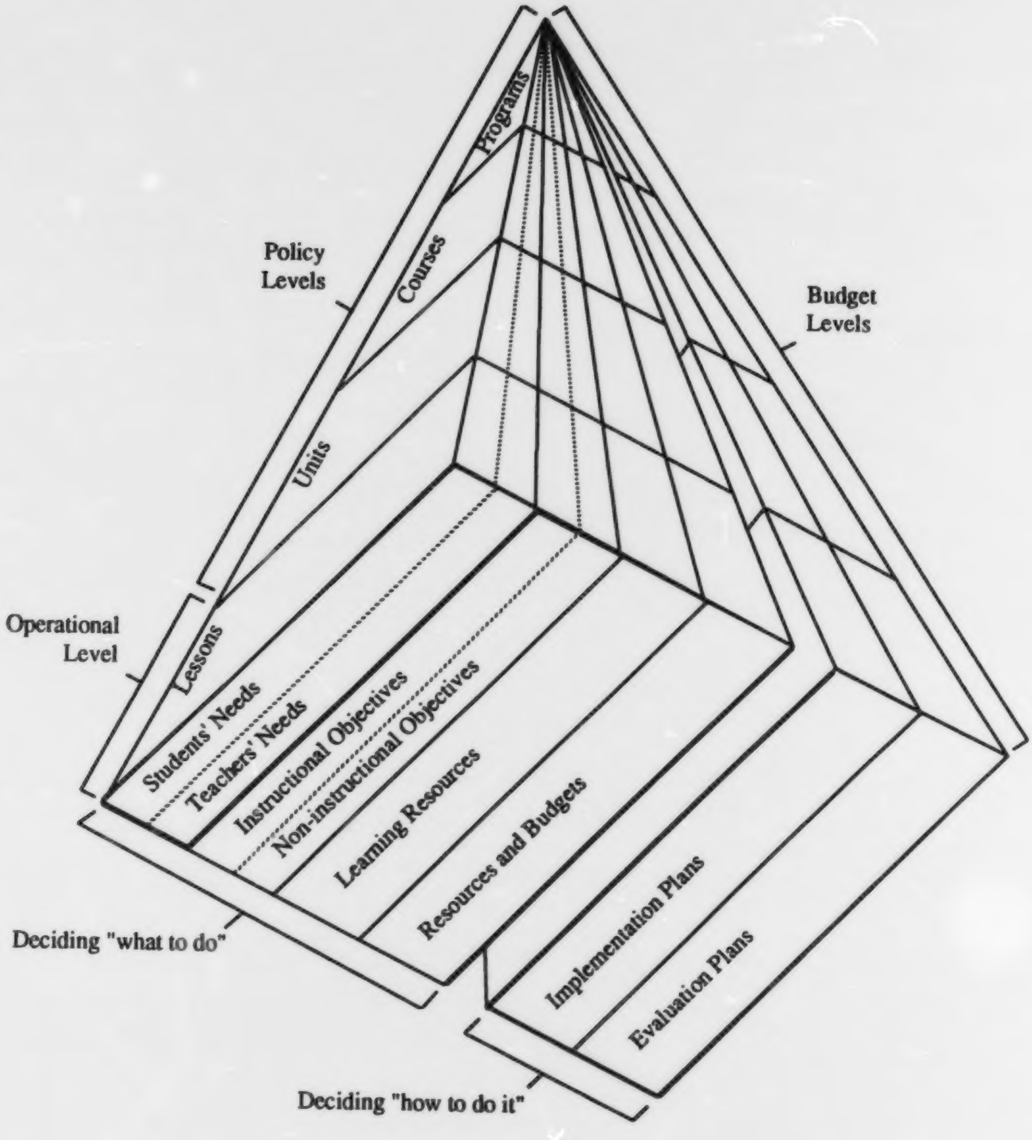

Programs
Courses
Policy Levels
Units
Lessons
Operational Level
Budget Levels
Students' Needs
Teachers' Needs
Instructional Objectives
Non-instructional Objectives
Learning Resources
Resources and Budgets
Implementation Plans
Evaluation Plans
Deciding "what to do"
Deciding "how to do it"

Figure 13. Levels of information which may be aggregated in a network-based system.

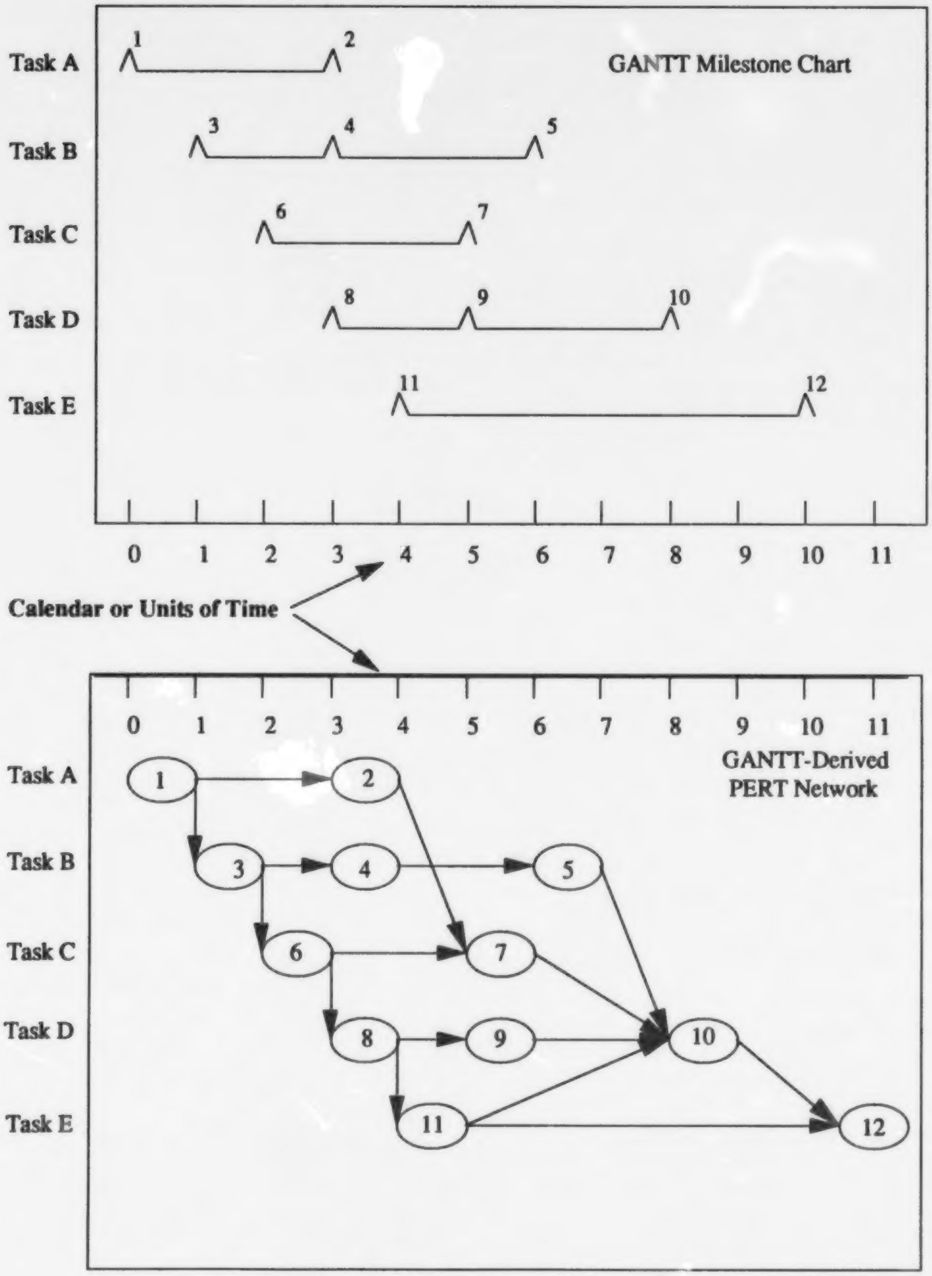

Task A
Task B
Task C
Task D
Task E
GANTT Milestone Chart
1
2
3
4
5
6
7
8
9
10
11
12
0 1 2 3 4 5 6 7 8 9 10 11
Calendar or Units of Time
0 1 2 3 4 5 6 7 8 9 10 11
GANTT-Derived
PERT Network
Task A
Task B
Task C
Task D
Task E
1
2
3
4
5
6
7
8
9
10
11
12

Figure 14. Calendarized PERT network derviced from a Gantt Milestone Chart.

Problem

Optimize the number of computer work stations required to accommodate five minute periods of use by randomly-arriving students and with waiting periods no longer than five minutes.

	Time Periods (minutes) 5	10	15	20	25	30	35	40	45	50	55	60	Maximum Capacity	Number Served	Efficiency (%)
Arrivals per five minutes	5	11	12	8	3	10	1	7	11	14	3	5			
Number Waiting (overflow added to arrivals for next period)															
Waiting (4 systems)	1	8	16	20	19	25	22	25	32	42	41	42	48	48	1.00
Waiting (8 systems)	0	3	7	7	2	4	0	0	3	9	4	1	96	89	0.93
Waiting (12 systems)	0	0	0	0	0	0	0	0	0	2	0	0	144	90	0.63

Summary (Best Solution: eight systems)

- Efficiency - 92.7 percent utilization
- Only one student waited more than five minutes (see 50 minute column, nine(9) arrivals and a capacity to handle eight (8))

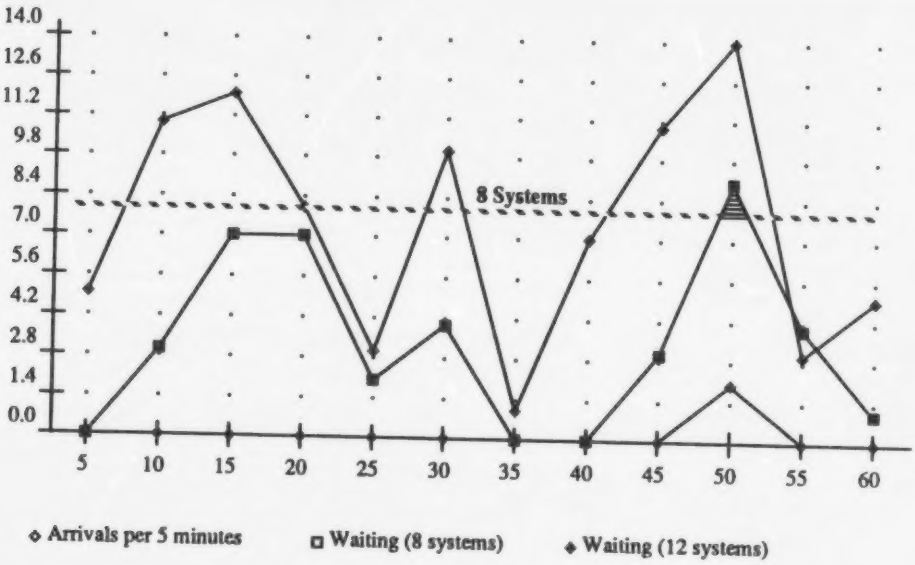


Figure 15. An example of queuing theory used to determine the amount of equipment required to support a randomly-arriving student population and without excessive delays.

computer work stations operate at 93 percent efficiency. Use of 12 work stations provides service to only one more student. While no one waits more than five minutes, the overall efficiency of the 12 work stations drops to 63 percent.

Games theory. Games theory is a mathematical method for dealing with decision-making in a competitive mode.

Dynamic programming. This technique places emphasis on the fact that optimum decisions must be made at several points in a multi-stage problem.

Simulation. Simulation involves systematic delineation of behaviors expected in the situations under examination. Simulations are used when calculations are impossible and the technique may find an application in computer-based learning systems in such subject areas as science, environmental impact assessments and social studies.

Reliability and Quality Control

One of the tasks of an educational administrator is planning and one of the purposes of educational planning is to use more effectively the resources available within schools or school systems. Resources refer to all goods and services available within the limits of the budget. Of a typical school budget, upwards of seventy percent may be allocated to human resources and it is important for educators to be able to plan for the reliable utilization of these human resources.

Reliability and human factors analysis techniques are well suited for inclusion as an integral part of educational planning. The conventions recommended for use in these studies are adopted from the fields of reliability engineering and human factors analysis.

Reliability means doing a specified job without failure.

A component may be defined as a discrete piece of a system and component reliability may be defined as the probability of a component performing a specified function, without failure, and under given conditions for a specified period of time. Since component reliability is expressed as a probability, it provides a numerical basis for rationally predicting the performance of systems comprised of components.

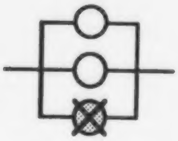
Reliability studies involve use of three models or ways of describing the relationships components in systems have to each other: the serial relationship, the redundant or parallel relationship, and the complex relationship.

Serial models. If a system is composed of *n* components with series failure dependency (failure of any component causes a total system failure), and if failure of any component is independent of another, the reliability of the system is the product of its component reliabilities:

$$P_S = P_1 \times P_2 \times \dots P_n$$

where P_S is the system reliability and $P_1, P_2 \dots P_n$ are component reliabilities.

When components are in series, reliability improvements may be obtained by: (a) derating the use of available components, (b) providing for redundancy, and/or (c) reducing the number of functional components.



Parallel (redundant) models. When components are arranged in a system in such a way that the system performs the intended function when any one, or more, of the groups of parallel elements is operating, the arrangement is considered to be redundant or parallel. Since reliability P is a probability on the scale of zero (impossibility) to unity (certainty), unreliability Q may be defined as:

$$1 - P$$

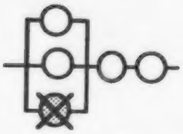
or by

$$P + Q = 1$$

thus, reliability of a parallel or redundant system is:

$$P_s = 1 - (Q_1 \times Q_2 \times \ldots Q_n)$$

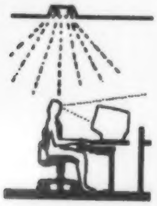
where P_s is the system reliability, $P_1, P_2 \ldots P_n$ are component reliabilities, and $Q_1, Q_2 \ldots Q_n$ are component unreliabilities (i.e., $Q = 1 - P$).



Complex models. Complex systems are comprised of a number of branches, some serial and some redundant. System reliability is calculated by applying both serial and redundant calculations, as appropriate. Examples of series, parallel and complex models are shown in Figure 16.

Human Factors Analysis (Ergonomics)

Human factors analysis leads to comfortable working conditions.



A number of factors capable of influencing how a person might function in a particular task or role are identified in Table 1. These factors fall into two categories, individual or internal factors and environmental or external factors -- factors that the individual brings to the work site and factors that are inherent in the work site itself. The individual factors may be subdivided into physiological factors which cannot be changed and idiosyncratic factors which are subject to some change. The environmental factors include organizational factors, social factors, physical factors, and function (task/method) factors.

The way in which some of these factors might relate to a particular situation is demonstrated by the following example.

Example

Task: Students in a class are to create sentences using words written on a blackboard. Consideration of the requirements of the task and the nature of the students could result in the following statements.

Given that:
(a) under a particular level of illumination, any member of the class can read handwritten words on a blackboard correctly in 95 cases out of 100 ($P_1 = 0.95$), and

Total Reliability (A to B) = .9 x .9 x .9 = .729

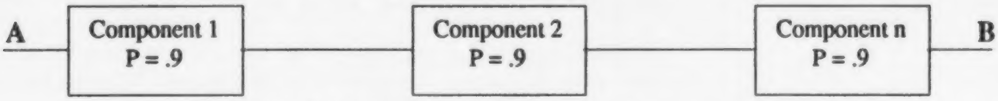

A
Component 1
P = .9
Component 2
P = .9
Component n
P = .9
B

Figure 16a. Reliability calculation for a three-grade course sequence.

Total Reliability (A to B) = 1 - (.1 x .1 x .1) = .999

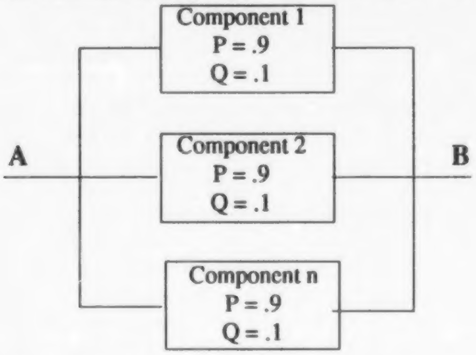

Component 1
P = .9
Q = .1
A
Component 2
P = .9
Q = .1
B
Component n
P = .9
Q = .1

Figure 16b. Reliability calculation for a single course with three alternatives.

Total Reliability (A to B) = 1 - (.271 x .271 x .271) = .980

(Reliability (P) of each program = .729 and Unreliability (Q) = .271)

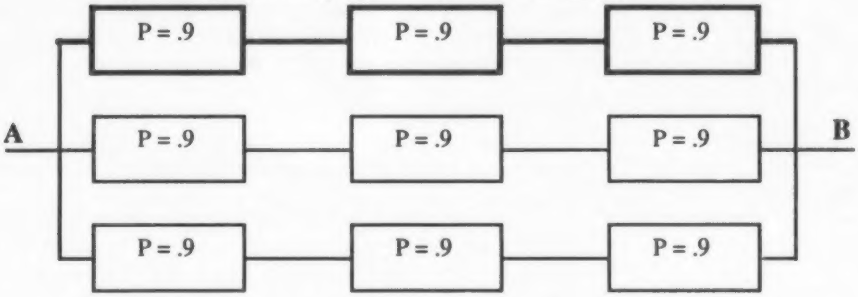

P = .9
P = .9
P = .9
A
P = .9
P = .9
P = .9
B
P = .9
P = .9
P = .9

Figure 16c. Reliability calculation for three programs, each containing three grades.

Total Reliability (A to B) = .999 x .999 x .999 = .997

(Reliability of each grade = .999 (see (b) above))

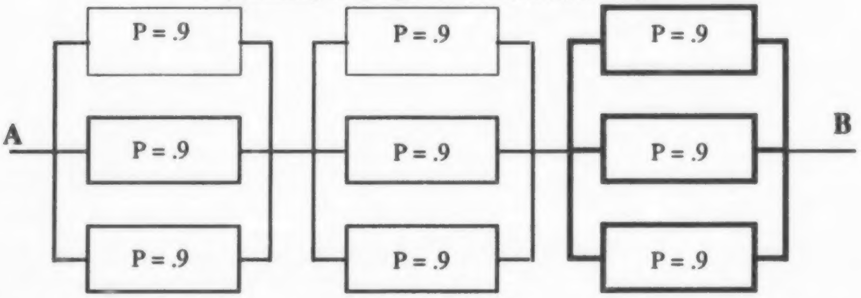

P = .9
P = .9
P = .9
A
P = .9
P = .9
P = .9
B
P = .9
P = .9
P = .9

Figure 16d. Reliability calculation for three grades amd three programs (treated as components).

Figure 16. Variations in levels of reliability based on different course/program configurations.

Table 1. Factors influencing human performance.

Individual (Internal) Factors		Environmental (External) Factors			
Physiological Factors	**Idiosyncratic Factors**	**Organizational Factors**	**Social Factors**	**Physical Factors**	**Function (Task/Method) Factors**
• Height • Weight • Motor capability • Handedness • Length of reach • Speed • Dexterity • Hearing • Vision • Age	• Skill • Motivation • Attitudes • Needs • Memory - short term - long term • Intelligence • Sensory capability • Experience • Training	• Level of activity in the hierarchy - executive - middle management - foreman - worker • Nature of involvement - individual - group - size - permanancy - leadership style - authoritarian - democratic - laissez-faire	• Incentives - none - individual - group • Feedback • Social needs	• Documentation and instrumentation • Illumination • Noise • Temperature • Vibration • Humidity • Workspace • Equipment - simple - complex	• Simple tasks • Complex (decision-making tasks) • Vigilance tasks • Control tasks • Emergency behavior • Isolated acts • Operator incapacity - death - falling asleep • Discrete activity • Continuous activity • Time available

(b) any member of the class can read and understand all of the words written on the blackboard in 95 cases out of 100 (P_2 = 0.95),

Then:
the overall reliability of each student correctly reading all of the words correctly would be 90.25 percent as calculated by the formula associated with the Series model:

$$P_1(.95) \times P_2(.95) = .9025$$

If the desired overall reliability in the example was set at 95 percent (0.95), then several alternatives could be used to improve the predicted reliability of 0.9025: (a) improve the lighting to a more optimum level, (b) provide more study of the words to be used in order to increase the students' ability to read and use the words correctly, or (c) augment words written on the blackboard with some other mode of presentation (perhaps orally) in order to provide redundancy.

The following is a suggested planning sequence which includes consideration of some aspects of human factors analysis on human performance.

Step 1. Develop the plan required to achieve a particular goal. Reduce the plan to a flowchart in order to identify the serial, parallel or complex relationships among the tasks and roles.

Step 2. Specify the acceptable degree of risk or failure, or, specify the required probability of success (reliability) for the entire plan. Allocate reliability estimates to each of the tasks and functions in the plan.

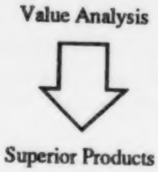
Step 3. Using the assigned reliability figures obtained from Step 2, calculate the expected reliability of the plan.

Step 4. If the calculated reliability figures fall outside the specifications established in Step 2, attempt to improve the plan by derating tasks, introducing redundancy, or by simplification of the plan. This process must be continued until the specifications are met.

Step 5. For each task in the plan, specify the human factors that are critical. Refer to Table 1. In each instance, consider the probability of failure attributable to each factor. Select personnel on the basis of the lowest possible risk.

Step 6. Implement the plan as specified.

Step 7. Evaluate the plan and the staffing used to fill the roles. Note any discrepancies or departures from the expected norms -- for example, the personnel were over/underrated. Use this data in subsequent planning cycles.

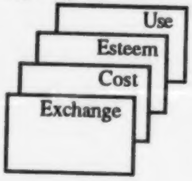


Value Analysis

The basic value analysis technique was developed at General Electric in 1949 and it was used to save the U.S. Navy a substantial amount in ship building costs. Value analysis (as a cost reduction or cost minimization technique) involves an appraisal of the functions performed by parts, components, products, equipment, procedures, services, and so forth and represents a search for a lower cost alternative for attaining that function. Presently, this technique is being applied in other industries, especially in the construction industry. The technique may also be relevant to education.

Value analysis is an organized creative approach which has as its purpose the efficient identification of unnecessary costs. It is an organized effort directed at analyzing the function of an item for the purpose of achieving that function at the lowest overall cost. The value analysis process involves an in-depth study of a project or program to determine its functions, its performance, its durability, and its reliability, and to find the least costly solution for achieving a set of predetermined requirements.

Types of value:



Value analysis is based on four types of values: use value, esteem value, cost value and exchange value. Consideration of these types of values is essential in the process of quantifying the elements of product cost as they relate to value. These terms are further defined as follows:

Use value. The properties and qualities by which the product accomplishes its intended function(s).

Esteem value. The properties, features or attractiveness of the product which causes the clients to want, own, or use it.

Cost value. The amount in dollars or man-hours that must be paid to purchase or to produce the function.

Exchange value. The properties or qualities which enable the clients to exchange the function or product for something else they want.

These values may be tested by asking a series of questions: Does it contribute to value? Is its cost proportionate to its usefulness? Can another standard product or function be substituted? Is there any better product or function available?

The principles of value analysis are being increasingly used in construction and modern industrial production. One misconception about value analysis is that it cheapens the products or functions. Contrary to this misconception, value analysis emphasizes genuine cost optimization with trade-off studies done between cost elements and all aspects of performance.

Value analysis identifies high cost areas during early stages of design and development and enables the incorporation of alternative designs into the final product without incurring excessive redesign or redevelopment costs and with minimum or no delay in design and development schedules. Value analysis may also be used to identify costly steps in repeated sequences or processes -- year-to-year or class-to-class educational strategies and practices, for example.

Value analysis occurs in phases.

The implementation of a value study requires the breakdown of a project or program into steps or functions, then ways must be devised to perform these steps or functions at a lower cost. Each value analysis team consists of professional specialists from a variety of disciplines and each team goes through several phases:

- Informational phase: get all of the facts and determine the functions of the project or program.

- Functional phase: ask questions. Describe the basic functions in noun/verb relationships (e.g., knife cuts, mixer blends, student writes reports). Use functional analysis techniques to eliminate unnecessary quality and costs but retain necessary utility and performance. Distinguish between needs and desires.

- Creative phase: use brainstorming and other creative and lateral thinking techniques to identify other ways to accomplish the function. Care should be taken to avoid judging ideas as they are expressed during this creative phase of the value analysis program.

- Judicial phase: evaluate and judge each idea for merit.

- Developmental phase: select the best idea and develop it in detail. Determine its cost effectiveness and test the idea if necessary.

- Presentation phase: sell the idea on its capability to meet functional requirements and life cycle cost benefits.

- Implementation phase: incorporate the approved change into the plans and specifications for the program or project.

- Follow-up phase: report program costs and net savings. Monitor end results to see if goals have been achieved.

Recognizing and overcoming roadblocks are important facets of value analysis. In value analysis methodology, cost optimization is achieved through a systematic breaking down of the total task and overall cost budget into packages of progressively decreasing size and then developing alternate proposals for isolated high cost areas.

Twenty percent of a program accounts for eighty percent of the costs.

A rule of thumb suggests that 20 percent of the elements in a project or program account for 80 percent of the cost and value analysis achieves the biggest savings by focussing on the small number of important but costly elements.

Value analysis is the technique of obtaining the most value for the money spent. As a consequence, the value analyst is concerned with investigations, fact collection, and analysis as well as following the practical application after modifications.

The value analyst utilizes a wide range of disciplines from statistical sampling to practical product design. During many value analysis applications the value analyst will involve accounting, design, cost reduction, engineering, manufacturing, management, purchasing, quality control, and selling because the ultimate results of the work will probably influence all theses aspects of the product or process. The value analyst must have the ability to direct, re-assemble, and re-define.

He must excel in inspired flexible thinking which is often otherwise lacking. He must know about the functions and materials and their performance in a wide variety of applications.

A value analysis program is intended to produce superior products or processes when compared to those that remain unexamined. Value analysis focuses on optimization of performance of the products or functions in terms of cost and time. The value analysis methodology enables the incorporation of alternate proposals into the final designs without incurring re-design costs and loss of time. A restriction placed on analysis is that the final costs are not allowed to exceed the established budgetary limit. Value analysis enables identification of the costs of different components in the project or function at an early stage. This knowledge helps to make sound judgements about requirements. Value analysis is oriented towards improvement with an emphasis on cost and time saving.

Planning and Evaluation Systems

Tools for improving the allocation of scarce educational resources.

The complexities of education and educational management create an ever-increasing need for management information and this need is felt both by the central governments and by school boards across the country. Inasmuch as this is the case, a brief review of literature relating to planning, programming, budgeting systems and resource allocation models is included here.

Because of the general need for improved allocation of educational resources (i.e., to improve accountability), several educational planning, resource allocation and decision-making systems were developed in the 1970s to meet certain criteria (Curtis 1971:27):

- The system for education is to be responsive to the society of which the school is part.

- The system for education is to be alert to the changing needs of students in a dynamic society with rapidly changing values.

- The system cannot ignore the future as though the future is to be the same as today.

- The system for education is to be developed by making choices among alternatives in the face of limited resources.

- The system is to provide for an analysis of consequences to illuminate the selection of alternatives.

- The system for education is to account for the resources it uses in light of the public trust for a human mind.

Financial information systems may be incorporated into an overall planning framework.

Several acronyms have emerged for these information systems. PPBS (or PPBES) models include planning, programming, budgeting (and sometimes evaluation or analysis) components. Some systems place emphasis on collection of management information and are known as planning, programming, budgeting, information systems (PPBIS). Others focus on only standardized accounting categories and are sometimes referred to as program account budgeting systems (PABS).

Still other systems focus on resource allocation and accountability and are referred to as educational resource management systems (ERMS).

PPBES and ERMS are the most complex systems--PPBIS and PAB systems being somewhat scaled down versions of the fully-fledged PPBES systems. They do, however, have a potential for being upgraded in the future to fully-fledged PPBES systems. Regardless of the scale of system development, all PPBES- or ERMS-type systems should be carefully planned and designed.

Most of the resource allocation models developed in the 1970s had common attributes, and according to Barro (1972:20), two of these attributes make PPBES models worthy of the educational decision-maker's attention: they display information in a manner that will be more meaningful to decision-maker's; and they provide information for purposes of systems analysis (systematic review and evaluation). Thomas (1971:25) identifies seven attributes of a good program budget (the core of a PPBES model):

- The program budget contains an explicit listing of services to be performed or objectives to be attained.

- Wherever possible, resources are allocated in order that these objectives may be maximized. For this purpose, scientific procedures such as cost-benefit, input-output, or cost-effectiveness analysis are used.

- Program budgeting includes procedures for evaluating the degree to which objectives are achieved.

- Program budgeting includes the allocation of resources and the projection of goals for a period of more than one year. Hence program budgeting may be thought of as a planning instrument.

- If properly carried out, program budgeting includes the identification of alternate methods for reaching a given objective or set of objectives. The "best" alternative is selected through some variation of input-output analysis.

- Program budgeting requires the development and use of sophisticated information systems.

- The use of program budgeting does not diminish the need for other kinds of budgets, such as those in common use today. Computerized information systems permit a given piece of information (say, an expenditure or revenue item) to be entered into more than one budget format.

PPBES models differ from the more traditional budgeting systems which often focus on line items and objects of expenditures (e.g., salaries, fuel costs, equipment, supplies and etc). In these traditional budgeting systems it becomes very difficult to draw cost comparisons between alternative programs and approaches. Moreover, traditional budgets are usually planned on a year-by-year basis. Budgets developed in PPBES systems generally are developed to reflect a multi-year planning horizon.

To Mann (1975:88) the main features of a planning, programming, budgeting system are: (a) a comprehensive data base about the organization's resources and the effect of their application; (b) a goal structure that is integrated with specifically stated objectives and then with the programs that are intended to meet them; (c) a systematic review of the total costs and benefits of existing and projected activities; (d) a procedure for the systematic generation and consideration of alternative activities; (e) multi-year planning horizons, and (f) continuous review of existing programs.

A PPBES model categorizes an organization's information according to the organization's objectives.

At the heart of any PPBES-type model is the program structure: "... an array for showing the priority of learning outcomes through the organization of program emphases; the format for the program budget" (Curtis, 1971:341). Barro (1972:21) defines a program structure as follows: "... a program structure is a classification system that categorizes the activities of an organization according to their relationship to the organization's objectives." A program is defined as "... a series of interdependent, closely related services and/or activities progressing toward or contributing to a common objective or set of allied objectives" (Curtis, 1971:340). The program structure determines the manner in which individual financial transactions are sorted, grouped and totalled to produce summary information of a useful nature.

A program structure must flow from the philosophy, goals and objectives of an organization. Indeed, according to Barro (1971:21-22) a program structure should have the following properties:

- The program structure should embrace all the activities of the organization.

- The program structure is a hierarchical classification scheme. District activities are grouped into a relatively small number of programs; these are subdivided into more narrowly defined subprograms; and the subprograms, in turn, are composed of still more narrowly specified elements.

- The program structure should allow and reflect differences in how directly activities relate to objectives. In some cases the relationship is clear and direct. For example, instruction in reading contributes to attainment of the objective "learning to read". However, many district activities make their contributions in much less obvious and direct ways. For instance, supervision of instruction by the principal and provision of electric light in the classroom also contribute to "learning to read".

- The program structure should be made up of categories that remain relatively stable over the years, so that long-range planning can be carried on; but it should also be able to accommodate new activities when necessary.

The program structure, according to Hartley (1968:154) "... makes the outputs of a school district visible and identifies the resources required to yield these outputs." He (Hartley, 1968:160) continues:

> *Where does one look for ideal program structures? Several systems analysts have observed that 'programs are not made in heaven'; rather they are imposed on the natural world by man. If an educator wishes to use a program structure, probably he will have to develop one himself, with or without divine intervention. After some familiarity with PPBES, the next step is to get on with the business of structuring the activities of the organization within a workable number of programs,*

> *meaningfully defined. 'There are as many different ways of putting together a program structure as there are people who will attempt it. It is very difficult to formulate generally acceptable specific 'rules' for constructing one.... The basic principle of an objective-oriented program structure is the grouping of activities that serve the same purpose.... The top-most level of a program structure should consist of broad categories directed toward the fundamental objectives of the jurisdiction.... The lowest level in any structure would be comprised of programs that have been implemented as a specific means for moving toward the end objectives.'*

It has been observed that many program structures are uni-dimensional. However, second, third and fourth dimensions may be added as appropriate. Each dimension provides another way of classifying and describing aspects of educational programs -- another way of developing and reviewing alternatives.

A four-dimensional model might include: subjects of instruction, student levels, student types, and locations. From these four dimensions any of the following 14 combinations may be selected for analysis: (a) subjects; (b) student levels; (c) types of students; (d) locations; (e) subjects x student levels; (f) subjects x types of student; (g) subjects x locations; (h) student levels x types of students; (i) student levels x locations; (j) types of student x locations; (k) subjects x student levels x types of student; (l) subjects x locations x types of student; (m) student levels x locations x types of student; and, (n) subjects x student levels x types of student x locations.

While it is clear that a total of 14 combinations may be identified, not all combinations are useful. Most important, educational outcomes should remain in clear focus and standardized units should be identified for comparison purposes (e.g., dollars per pupil, dollars per pupil per location). These comparisons may be made against other similar activities or against a general plan.

No attempt is made to identify a "best" program structure for school districts. Clearly, the program structure should be formulated around the expressed goals and objectives espoused by each school district. At the same time centralized information system needs are rooted in the information collected by school districts -- that is to say, there is a need for integration. Major programs should become the common basis for aggregated centralized reporting and thus they also become the basic units for inter-district analysis of common expenditure types.

Summary

Educational technology was defined as an applied science that encompasses: hardware and software, management sciences, extant theories of curriculum and learning, and skilled human resources. In order to facilitate development of a vision of educational uses of technology in the future, the educational potentials of a number of hardware and management science technologies were assessed and some applications discussed. The next chapter is devoted to description of a vision of education in the future.

Chapter 6

A New Vision of Education in the Future

The Composite Scenario: A Second Look

The Composite Scenario is founded on three sets of interrelated factors: trends, contemporary problems, and barriers to educational change.

The trends. A number of trends are becoming very apparent today and these trends have significant implications for education.

Technology can be used to manage both information and activities.

1. Technology today, and as it has been throughout the ages, is a prime mover for change, and each technological advance has changed the way work is done in a society. Technology today has a tremendous potential for managing extensive amounts of information and for controlling or managing completion of routine and repetitive tasks.

2. The industrial models are rich with technological innovations, communication capabilities, and management sciences.

3. Competition is beginning to appear on the educational horizon -- competition coming from the private religious schools and from the private sector with its franchises and panaceas for education.

4. Economic/political turbulence or instability is causing concern in some quarters and it is forcing some belt-tightening and a reexamination of priorities.

5. Society is becoming increasingly fragmented. There are more and more identifiable minorities or interest groups in our society and each is demanding its rights. Steps must be taken to integrate these groups and the people they contain into a cohesive social structure.

6. More and more of the students in school need help with the process of integrating information into their understandings and frames of reference.

7. Few decisions can be made in isolation. There is a need to recognize that all decisions are ultimately linked together. A decision made here

today, will have an effect elsewhere tomorrow. This interrelatedness of decisions must be incorporated into future planning.

8. There is a transformation in the role knowledge plays in society. What land was to the agrarian society and money to the industrial society, information is to our post-industrial (information) society.

Contemporary problems. In company with these trends are a number of educational problems.

1. The rising costs of education are giving cause for concern because they are not closely and demonstrably linked to increases in educational productivity. This inability to link educational inputs and outputs is creating demands for some form of accountability.

Ideals about the uniqueness of students are lost through cohort-processing.

2. If someone tried to develop a description of today's students by watching how they are processed in schools, they could easily conclude that students are perceived by their teachers as being identical in many respects -- identical as to preferred learning styles, learning readiness, experiences, expectations, aspirations, and so forth. While research and experience tells us the exact opposite about students -- each one is unique -- we find them being processed in cohorts or batches. Little attention is given to individualization. Unfortunately, the present educational delivery system appears to be unable to provide adequate educational choices for individuals or to meet some of the needs of individual learners (e.g., accommodating different learning styles, learning readiness, or the time allowed for completion of specific educational objectives). Indeed, students have relatively little choice in selecting the program and the delivery style most appropriate to them. Students continue to be processed in cohorts with individuals being screened at the end of the term for advancement or recycling. Rather than requiring students to repeat inadequate work completed during the last hour or the last day, for example, they are expected to repeat entire school terms.

3. There are substantial program inequities between large urban and small rural districts and schools.

Barriers to change. These trends and problems are putting pressure on education to change. Unfortunately, there are also a number of forces at work to inhibit significant change in the short term.

There are vested interests in the status quo.

1. Educators have a vested interest in maintaining the status quo -- a labor-intensive educational system. Collective bargaining seeks to preserve these interests.

2. The inertia of the education system is sufficiently high to inhibit significant change.

3. Most educational changes carry a relatively high price tag. This high cost of educational change is another inhibiting factor, even when it can be shown that the change will have lower life-cycle costs than other alternatives, including the status quo.

Educators don't know how to use technology and they don't trust the experts.

4. There are relatively few educators capable of fully utilizing the potentials available from technology and communications. Moreover, educators are reluctant to specify an appropriate technological delivery system and then let the experts in technology or communications design the system. Rather, the educators try to design the technological systems and end up in failure or with very inferior products.

Each of the scenarios identified in Chapter 2 has something to contribute to a Composite Scenario and our understanding of education in the future.

The Superindustrial Scenario was proposed as a response to the pressures introduced by technology (hardware, software and human resources) and competition. The competition emerges in response to unfulfilled demands for two kinds of choices -- choices within the education program (content) and choices in the way the educational programs are delivered (process).

The Authoritarian Scenario was proposed as a response to the need to demonstrate accountability and good stewardship of public funds. It was called "authoritarian" because it was believed that someone or some agency must take control and restore public confidence in education (i.e., take charge and turn the tide of rising educational costs and declining educational outputs).

The Ecological Scenario contributes a sensitivity or awareness to the need for integrating all of the resources currently available in our society. No longer can we afford to ignore the potential contributions that a diversified population (with all its minorities) can offer.

A Vision of a Technologically-Enhanced Educational Alternative

Henchey (1986b: 21) contends that there is a need for educational systems capable of supporting a learning society with its diversity of educational needs.

Toffler (1970: 266-267) challenged educators to exploit technology and to use it to provide for the individualization and customization of educational programs. Looking beyond today towards tomorrow, one is able to glimpse Toffler's view of an entirely transformed educational system -- an educational system that provides quality education, equity in terms of program availability and in spite of geographic or regional differences, and customized delivery with each student pursuing his or her own educational pilgrimage. As education becomes more and more a lifelong pilgrimage, one sees students exiting and reentering the educational system many times. The sharp demarcations found today between study and work become less clear and less important in the future. Some students will regularly and concurrently engage in both.

Customization and individualization of education to the extent that it enables students to engage in their individual educational pilgrimages will alter many other aspects of today's educational practice in the future. Teachers will have far less responsibility for providing information and more responsibility for helping students find, evaluate, and use information from a variety of sources.

The curriculum will be changed to meet the many constraints imposed by individualized and customized educational programs. The more or less amorphous mass that is the curriculum today will be carefully, mapped, charted and organized so that it can be managed technologically. The learning resources that constitute a major part of the applied curriculum will be redesigned and tailored to specific learning objectives or curriculum modules. Students will be able to satisfy their unique learning styles and interests by selecting from a wide array of carefully designed learning resources. Well developed learning resources will be shared among many learning systems -- they will be able to transcend boundaries.

A vision of education in the future should be based on today's proven technology.

This vision of a technological alternative for education is based on the use of presently available resources and not on a vision of what technology might be like in the future. Experience tells us that most of the installed technological systems, for example, radio, television, telephones, computers, and so forth, will continue to exist. While television has improved immensely in the last 30 to 40 years, the earliest television sets will still receive the more complex transmissions broadcast today -- they continue to function to their original design specifications. What has happened is that improvements to picture quality, color, stereo sound, captioning, and so forth have been designed and added while still maintaining compatibility with existing systems. This trend can be seen in a number of other areas and it will continue. As a consequence, educational planners can be relatively certain that decisions made today will have some futurity inasmuch as new developments will be designed to be compatible with existing systems.

The vision of education in the future that is described here can most easily be understood by either setting some clear goals or by comparing and contrasting with education as it is practiced today.

Students entering school today are experientially older than were their parents when they entered school.

Today's educational programs are generally described in terms of prescribed courses through which all students are expected to progress in cohort or lock-step fashion. While this process has worked reasonably well for many students in the past, the process does not adequately meet the needs of many of today's students -- perhaps a reflection of the fact that the characteristics of students entering these programs are different today than they were several decades ago. There is an on-going expansion of the life experiences of all people -- children included.

> *The expansion is not measured in terms of clock time, but in terms of experience, or what we might call subjective time. For a living being, time seldom passes according to the clock but it is judged in terms of experience. This is an interesting paradox here, in that time spent in interesting pursuits passes rapidly, whereas time spent in illness drags. Yet in recollection, we exactly reverse this and we remember time largely in terms of interesting experiences. But it is recollection that counts, since that is when stored information is used. Thus, the paradox is resolved in that we may conclude that more experience and more information are subjectively equivalent to a longer life.*
>
> *To carry the thought further, consider a man who had lived 70 clock years from, say 1850 to 1920, and add up his potential experience as a measure of 70 experience years. His grand*

> *children, living from 1910 to 1980, could if they fully absorb their potential of information (experience), easily exceed 400 experience years. Their children, 1970 - 2040 A.D., may exceed 700 experience years.*
>
> (Herold, 1970:23)

How many educators are there today who act as though today's children, at school entry age are, experientially speaking, older than their counterparts at the turn of the century by a factor of ten or more? How many schools are there that can boast a curriculum capable of keeping pace with the exponential rate of social change and resulting increases in new knowledge? Most of the reports are pessimistic.

The uses of technology in education in the past has been as an add-on to the prevalent educational delivery method of the day. The most common use of computers in classrooms is for computer-assisted instruction (CAI) which is essentially a substitute for the teacher in such routine activities as tutorials and drill and practice. Little attempt has been made to try and use available technology to solve some of the larger education problems. The potentials of technology must be further exploited. Technology must be used to change the way things are done in education. When technology is used to alter the way education is delivered, a number of benefits should accrue. For example, a technologically-based educational delivery system will meet the following criteria:

Technology increases:
- *possibilities*
- *productivity.*

- Lower educational costs and increase educational productivity. In many cases technology will be used as a substitute for labor, or at least certain kinds of labor -- especially the kinds of labor that are repetitive and routine.

- Include a curriculum that is integrated with a number of other components (instructional management, learning resource management, curriculum evaluation, student evaluation, tracking and record-keeping, and linkages for state (provincial), district, school and classroom planning) and suited for implementation in a variety of ways (e.g., large group, small group, individualized; on-campus or off-campus).

- Utilize general purpose application software instead of high-cost, specific purpose CAI software. What is needed in education is a management tool as powerful and useful to education as the PERT and CPM management tools are in industry.

- Improve education and make it more equitable for students in small schools and students in rural and isolated areas.

- Accommodate a greater choice of programs and learning styles. (Today's students are still expected to progress in cohorts and to pass or fail on the basis of a year's work. For lack of mastery of a few objectives, students are usually required to repeat all of the objectives in a course or a program.)

- Be relatively immune to change or amenable to perpetual change? For example, an educational program should be structured so that elements can be added, revised or dropped without destroying the unchanged parts of the curriculum.

- Accommodate individualization, integration and innovation. Individualization and integration, on a large scale, will more likely occur after adequate classroom management tools have been developed and provided to teachers.

A vision of a technologically-compatible curriculum may be described as being analogous to a roadmap. A roadmap describing today's curriculum would reveal a limited number of roadways, few entry and exit points, few destinations, limited modes of travel, and few nodes, intersections or points of choice along the way. What appears to be needed are more roadways, more nodes or points of choice, more modes of travel, more entry points, and more destinations or exit points.

Mapping the objectives in the present curriculum, as a first step towards providing educational choice, would appear to be a nearly impossible task. Yet there is a technological solution that has already been developed and adopted widely in business and industry -- the critical path methodologies such as Program Evaluation and Review Technique (PERT) and the Critical Path Method (CPM). PERT and CPM are highly generalizable project management programs which are used on almost every major development project undertaken today. A similar kind of generalizable program could facilitate massive restructuring, reorganization and better management of the present curriculum development and implementation.

PERT enables lesson-by-lesson and concept-by-concept management of educational programs.

The use of a PERT-like technique could also serve to facilitate organization and management of programs, not on a course-by-course or unit-by-unit basis, but on a concept-by-concept or lesson-by-lesson basis. A reasonable estimate of the size of the curriculum can be obtained by means of some simple calculations. An elementary program spanning six years and comprised of six subjects would yield 36 courses. A three-year junior high school program comprised of nine subjects would yield 27 courses. At the high school level it might be possible to identify 150 subjects spanning three years -- 450 courses. These simple calculations suggest that the entire public school curriculum contains somewhere in the range of 513 courses. If each course consisted of 150 objectives, the total curriculum could be described in a single network with 76,950 interrelated objectives. Thus organized, the curriculum would contain a number of attributes not currently available in any other educational delivery mode. For example:

- The curriculum could be integrated: vertically (courses to units to lessons/concepts); longitudinally (the sequence of the curriculum concepts or objectives); and, horizontally (subject to subject).

- The most appropriate learning resources could be identified or developed and cataloged for each concept.

- Something similar to auto club "strip maps" could be used to depict, monitor and record student programs and progress. Indeed, these strip maps could be automatically developed by the program software for each student (on the basis of each student's profile) thereby creating what has come to be known as Individualized Educational Plans (IEPs) and frequently demanded in areas such as Special Education.

- Mechanisms could be built into the curriculum management software to: evaluate students performance at selected points throughout the curriculum, to evaluate the curriculum on the basis of student performance, and to report on teacher productivity.

- The curriculum could be designed so that it could be changed or modified without disruption to students in the program. Returning to the analogy of the road map, curriculum changes would be equivalent to detours -- only those near the detour point would be affected by the change. Those who have already passed the detour point are unaffected and those who are approaching the point would find a modified program when they arrive.

- The network-based curriculum could be developed centrally and implemented in a variety of ways, for example in large groups, small groups or individually and either on-campus or off-campus.

- Learning resources management could be integrated into the system and could allow for a great deal of individualization. For example, learning resources acceptable to the many different groups served by education could be selected for certain sensitive concepts and objectives. Similarly, second language materials, reading materials, and so forth could be selected on the basis of students' values and interests.

This attribute could have the effect of making the overall curriculum almost universally acceptable. Curriculum materials could be used far and wide with the result that resource costs could drop sharply, simply as a result of economies of scale. Moreover, private schools would not have a need to remain private, they could fit into public systems by selecting materials of their own choice for use in meeting the overall curriculum objectives.

This generalizable curriculum could also be shared across states and provinces. The overall set of curriculum objectives and associated learning resources would remain relatively constant with the learning resources selected to meet the individualized or localized needs. An American private school might choose from the available learning resources only those in standard US measures (inches, feet, for example), and resources reflecting an acceptable set of values and theories for a particular region or ethnic group. At the same time a student in Quebec or a French language student in Alberta might select materials prepared with metric measures and in the French language. One student might meet the reading appreciation requirements in an English course by choosing "historical" novels thus satisfying both a course requirement and a personal interest. Another student might meet the same objectives by using contemporary literary works.

In summary, the objectives of the curriculum might remain relatively constant and with wide application while an array of learning resources would open the way for program implementation by a wide range of interest groups and in a variety of ways (i.e., large group, small group or individualized).

Specifications for a New Learning System

Having described what the educational system of the future might be like, a set of specifications must be developed to guide its further development.

A well designed learning system should facilitate a number of important activities. It should organize the curriculum, enable the delivery of instruction in a variety of modes, monitor student progress, direct teachers and students to lessons and materials, diagnose and prescribe learning objectives, evaluate student outcomes, evaluate the curriculum, select test items from test banks, manage learning resources, and provide educational and curriculum planning information for educational managers at the classroom, school, district and provincial levels. Simply put, a good learning system should provide clear benefits for all users -- students, teachers, managers and administrators.

General Specifications

Learning systems will survive only if they provide benefits for all users: students, teachers and managers.

Benefits for students. A learning system yields student benefits to the extent that it: (a) outlines the scope of programs and courses they will undertake and the criteria by which they will be evaluated; (b) provides access to a summary of achievement to date; (c) provides direction or guidance in choosing subsequent learning objectives and suitable learning resources in keeping with their learning styles and preferences; (d) provides formative and summative tests of achievement based on the curriculum content being studied, and with immediate feedback of the results of performance on tests and lesson evaluations; (e) provides a description of the prerequisite skills required in any subsequent programs; (f) tests proficiency at pre-defined checkpoints throughout the curriculum; (g) provides review of acquired skills and proficiencies as necessary; (h) enables progress at individualized rates through use of learning resources matched to abilities, aptitudes and learning styles; (i) highlights problem areas; and (j) facilitates direct one-on-one assistance from a teacher or instructional aide.

Benefits for teachers. For teachers, a well-designed learning system: (a) provides a graphic view of the scope and sequence of the curriculum and the criteria by which student mastery will be assessed; (b) reduces the work involved in constructing, issuing and marking tests and recording the results -- the management system performs these functions; (c) provides snapshots of students' progress on a regular or irregular basis; (d) maximizes interaction with students on a one-to-one basis and enables provision of additional assistance to those students who are progressing at a rate which is slower than expected; (e) helps teachers to assist students in the process of program and career planning; (f) assesses the achievement of students on materials already covered but which serve as a prerequisite for the learning objectives to be undertaken; (g) provides access to student and teacher resources and professional development materials congruent with the curriculum; (h) provides access to up-to-date curriculum evaluation data so that problems with the curriculum and learning resources can be quickly corrected; and (i) enables demonstrations of accountability.

Benefits for educational administrators and managers. For administrators and managers at the school, district, and provincial levels, a good learning system should allow them to: (a) access student achievement results (individually, or by groups) at any time; (b) employ a planning framework into which the work of many participants may be incorporated into a significant whole; (c) reduce major discrepancies in program interpretation in both student expectations and evaluation criteria; (d) describe the program and learning resources to the public or other interested stakeholders; and (e) "tailor" courses and programs for individual students which are not necessarily bound to specific sites (i.e., classrooms) or to specific times (i.e., during regular class periods).

Benefits for learning system managers. For the learning system manager, the system should provide: (a) an authoring system that guides development of the curriculum and related resources; (b) feedback on the efficiency and effectiveness of the curriculum design and implementation modes; (c) mechanisms for highlighting problem areas; and (d) mechanisms for maintaining the curriculum at the highest possible state of currency and quality.

Finally, a good learning system should encourage and facilitate cooperation among a number of different groups and specializations in activities leading to development of a curriculum -- groups and specializations such as teachers, child development specialists, learning psychologists, curriculum writers, illustrators, and others.

Detailed Specifications

Detailed specifications for new learning systems may be discussed under three headings -- (a) essential attributes, (b) desirable attributes, and (c) attributes to be avoided .

New learning systems should be designed or selected to provide the following essential and desirable attributes, all having been found to be attainable in practice (i.e., these attributes are practical and not theoretical. They have been demonstrated in practice in manual modes of operation.)

Learning systems should increase productivity and foster continuous student progress.

Essential learning system attributes. In order to improve educational productivity and to facilitate individualization (or continuous progress), a learning system must meet the following specifications:

1. Accommodate group instructional processes as well as individualization, customization of learning and continuous progress (i.e., the system should facilitate prescription and monitoring of Individualized Educational Plans [IEPs]).

Planning and monitoring an individualized or customized program should be as easy as mapping a journey or trip and recording progress based on recognized milestones. Moreover, well designed systems should provide tools for prescribing and monitoring Individualized Educational Plans (IEPs).

2. Render the curriculum as somewhat immune to obsolescence (i.e., it should facilitate curriculum revision and modification as necessary without requiring complete redevelopment of the curriculum).

Curriculum revisions and modifications should be analogous to highway construction detours. Traffic that has passed the detour is uninterested in the detour. Traffic approaching the detour will find the revisions and alterations completed. The only ones concerned with the detour are those few who happen to be at that location at the precise time the revisions and alterations are being made.

Nevertheless, learning systems cannot be built with the capability for rendering a curriculum immune to all pressures. Sometimes a curriculum must be replaced with one that better reflects our understanding of learning processes or better interprets a preferred philosophy.

3. Eliminate or minimize common and independent curriculum development activities often carried out by teachers in traditional settings (e.g., setting scope and sequence, lesson planning and preparation, learning resource development or selection) and integrate productive, but common, teacher activities into a comprehensive curriculum development, delivery, evaluation, and revision system.

Lesson planning, instructional resource development and testing are activities all teachers engage in to varying degrees. In many cases these activities are carried on concurrently -- many other teachers are doing the same things at the same time. Ideally, a learning system should either make these things available from a centralized source or integrate the teacher-developed instructional modules and related materials into a system that makes them available for sharing. In a sense much of the traditional lesson planning activity associated with traditional education delivery is replaced in learning systems by development of instructional modules. To the extent that lesson planning means attending to student needs, that is taken care of in Item 1, above -- preparation of Individualized Educational Plans.

4. Be more user-friendly than the educational systems expected to be replaced.

New learning systems should be supportive of students and teachers in their new roles; it should be easy for both to adjust.

5. Accommodate different theories and other variables (e.g., theories of child development and cognition, learning styles, management tools, and learning resources), for example:

- objectives based on different learning theories (e.g., behavioral, Piagetian);

- objectives catering to different learning styles (e.g., reading/writing, audio/visual, experiential, listening and speaking [oral], computer/media based); and

- objective management at different levels of specificity and duration (e.g., multi-periods [hours/days] and applicable to mature and gifted students, class period/hour or less and applicable to regular students, microsteps/minutes [of the sort associated with behavior modification or computer assisted learning]).

6. Support modularization of the curriculum and specification of the relationships among the modules in unambiguous terms. Modules should not be regarded as being equivalent to either chapters or units from texts or to themes (e.g., weather, energy conservation, etc.). Modules might be regarded as concepts or learning objectives.

Modularization of the curriculum is essential if the power of technology is to be used in educational delivery. The source of technology's power lies in its ability to support the subdivision (modularization) of an entity into many small pieces (modules) and to further permit their re-assembly into new and different entities.

A five credit course (representing 125 - 150 hours of work) might be expected to contain in the range of 75 to 150 interrelated modules or learning objectives, each with specified and measurable learning outcomes.

7. Provide a framework or vehicle for identifying or defining appropriate technology.

The nature of both the overall curriculum and each objective as well as the characteristics of the students should be used for defining the most appropriate technology for achieving each objective.

8. Foster student progress based on performance (not time spent in the course).

9. Provide for instructional (learning) resource management.

A learning system should be able to use, incorporate or integrate existing learning resources into the system (i.e., it should not be necessary to replace all existing instructional media with new media).

10. Provide for systematic curriculum evaluation and modification.

11. Provide the tools necessary for managing individualized programs (i.e., record-keeping systems, program planning tools).

12. Be at least as cost-effective as the learning systems which may be displaced.

Technologically-enhanced learning systems may require considerable front-end funding and support. In order to get a true perspective on costs, life-cycle costing techniques may be useful.

Desirable learning system attributes. Well designed learning systems should also meet these additional desirable criteria:

1. Provide clues and advance organizers to help students absorb new content and formulate conceptual frameworks and to grasp complex concepts and relationships.

Much of the present mediated instruction may fail to provide students with the necessary integrative frameworks required for organization of information. Moreover, teachers may not adequately introduce topics or discuss them after the mediated presentation. Without such a framework, students are forced to rely on rote recall in order to retrieve information (for example, at exam time). When suitable integrative frameworks are provided, students are able to recall blocks of information.

2. Demonstrate compatibility with a wide range of management science tools for purposes of management and quality control.

3. Accommodate integration of:

- subjects within the curriculum (within a course, course to course [longitudinal integration], and subject to subject [horizontal integration]); and

- students' experiences (i.e., students' fund of information and experiences should be considered during development of individualized programs).

4. Integrate technology and communications into the curriculum, as appropriate.

5. Support all subjects and all grade levels (i.e., pre-school to post-secondary) and capable of accommodating multiple exits and re-entries.

6. Support student/teacher choices of learning resources (e.g., metric, Imperial, US measures; language of choice; personal interests, cultural differences).

Learning system export products include:
- *learning resources*
- *educational services*
- *software.*

Marketability beyond regional, provincial or state borders is increased if students can choose the sorts of learning resources most appropriate to them. For example, much of the curriculum might remain the same regardless of whether a student is using metric, Imperial or US measures. At the same time it must be acknowledged that it is also essential to be able to "lock-out" these choices when they are inappropriate. For example, students in Alberta might use only those resources that employ metric measures.

7. Support a variety of different types of objectives (although not necessarily all at once), for example:

- experiential, performance, behavioral, social, attitude formation;

- knowledge-based, skill-oriented;

- cooperative, competitive;

- individual, small group, large group;

- cognitive, affective, psychomotor;

- acquisition, assimilation, review; or

- general to specific, specific to general.

Some learning systems should be avoided at all costs.

Undesirable learning system attributes. Just as a learning system should have some distinctly desirable attributes, there are some attributes to be avoided. A learning system might be regarded as weak or ineffective, and one to be avoided, if it has either or both of the following earmarks:

1. The learning system cannot be implemented in an entirely manual mode almost as easily and as effectively as in a technologically-enhanced mode.

2. The learning system relies on sophisticated equipment and high level user skills.

Selection of Instructional Media and Technologies

Selection of technologies (media) to support instruction should be made on the basis of the advantages the new technology offers over the older technology. (Technologies should never be adopted simply because they are available.) Moreover, the media form chosen to present curriculum content may be very critical. Ideally, the media form selected to present content should contain features or attributes which makes it easy to convey the structure and logic of the content being presented. Only after students have developed conceptual maps of information can they be expected to use the information in any organized fashion. Technologies are not all equally effective and equally able to facilitate learning.

Print media is a good standard for comparison.

The basic frame of reference for comparing alternative media forms might be print media which has the following attributes:

- inexpensive;
- available in full color as well as monochrome;
- easily copied;
- easily scanned, browsed, dog-eared, annotated, pondered and reviewed;
- transportable;
- storable in several forms (e.g., hard copy, microfiche);
- easily indexed and easy to access in a sequential or random mode;
- resistant to damage through use;
- usable under a variety of conditions, including locations that are not served by any services except light (which may be available natural light); and
- usable without the aid of a "user's manual" (i.e., use of print materials is widely understood and print materials may be used to their fullest extent without the benefit of additional support). In this regard, many learning resources require extensive pre-training before they can be fully used. For example, few computer software programs lend themselves to use without the benefit of reference to a "user's manual". Similarly, video recorders, interactive video disks, and other complex technological devices require frequent reference to operating manuals.

In addition to being more powerful than print materials, replacement technologies should also:

- increase possibilities (for students and teachers);
- minimize or eliminate scheduling problems;

- rely on common equipment and skills rather than requiring esoteric skills and expensive programs and equipment; and

- link learners with other learners and with a variety of resources.

Some Implications

Undertaking the development of a learning system such as the one postulated in this chapter (and discussed in more detail in Part II) has implications for all areas of the educational arena. Charp (1988: 32) identifies a number of actions that must be taken before technology can transform education.

Transforming education in any meaningful way requires a number of actions:

- preparing teachers to deal with the ever-increasing availability of technological tools;

- committing additional human and financial resources when and as required;

- educating the public on technological literacy -- encompassing computers, telecommunications, video, laser, and other technology;

- establishing partnerships between business and education;

- restructuring the curriculum to make effective use of technology;

- receiving financial assistance from the federal government to assist in research on the effects of technology on teaching and learning and on the transferability of model programs; and

- assessing what has been proved valuable not only in business but also in educational institutions.

Gardner (1988) observes that when it comes to issues of substantive change in education, "...the great need is for strategic (policy level) planning -- too much emphasis or effort has been on the delivery type of planning."

On the basis of experience gained through experiences on projects mounted during the accountability period (i.e., the 1960s and 1970s), Wolcott (1977: 241) warns that logical and rational systems often fail because they do not duly account for the things held to be important to those most directly involved -- and in this case it is teachers. Accordingly, development and implementation of plans leading to realization of the learning system outlined in this book must be undertaken carefully and with the full support of the principal players -- the students, teachers, and administrators that make up the educational system.

Summary

Technology is impatient and will not be held in abeyance. It will burst forth -- chaotically without planning.

Three things seem apparent. First, technology represents a force in education that may be held in abeyance for a short while but inevitably it will burst forth. Whether technology impacts education chaotically or in an orderly fashion is a choice that we can make. Second, education as it stands today, does not warrant a high grade on its report card. Many needs are going unmet while overall educational costs continue to rise. Third, technology has not yet changed the way things are done in education in any substantial way -- it hasn't made it past the classroom door. This chapter has suggested a Composite Scenario: a planned response to the trends and forces reshaping education. With this as a base and with a broad array of resources in mind a new vision of a transformed educational delivery system has been postulated. The vision of education in the future was further defined by setting forth a set of specifications to be used in developing a technologically-enhanced educational delivery system. Part II is devoted to a discussion of the steps to be followed in the development of such a learning system.

Introduction to Part II

Developing a Network-Based Learning System

Part II contains a description of the stages to be taken in developing a learning system that has the potential to harness technology in a way that meets and overcomes many of the shortcomings and problems encountered by educational delivery systems in use today. Specifically, a learning system is described which supports a number of delivery modes including individualization or customization of instruction. Because a transformed educational delivery system has implications for the physical environment as well as the instructional environment, some attention is given to the design of educational facilities that might be relatively immune to premature obsolescence as a result of emerging technologies and pedagogies.

The basic learning system described in the following chapters was conceptualized, developed and used in a manual mode a number of years ago, but only today do we have the tools -- particularly the computers -- needed to make the approach feasible on a large scale.

The ideas behind the network-based learning system began to fall into place the first day I walked into a classroom and faced a group of underachieving teenagers who obviously needed individualized programs. Having only shortly before left employment in the aerospace industry where we routinely used the Program Evaluation and Review Technique (PERT) to manage large-scale projects involving hundreds of engineers (all working towards a common goal) a question sprang into my mind, "Why can't something like PERT be used to help this class of twenty four students who really represent twenty four individual learning projects?"

By the end of that first year, a network-based science curriculum had been developed and put into use on a fully individualized basis. The basic parameters of the network-based learning system were reviewed and reported in a thesis (Hathaway, 1970). Soon a number of other small, manually-managed, network-based learning systems were developed and these served as the basis for a feasibility assessment of the approach (Hathaway, 1975). While the feasibility assessment results were very positive, the lack of sufficient computer power in schools and classrooms mitigated against any widespread adoption of the network-based learning system at that time. All that has now changed.

Today, with the availability of adequate computing power, universal availability of extensive telecommunications tools, and a wide array of management science tools, the network-based learning system represents an entirely practical educational delivery system with applicability in a variety of settings and contexts.

Chapter 7 outlines the steps to be followed in developing a network-based curriculum.

Chapter 8 deals with implementation of the network-based learning system in either a manual mode or in a computer-based mode.

Chapter 9 discusses evaluation methodologies suitable for evaluating the curriculum (including learning resources), students' progress, and teachers.

Chapter 10 considers the nature of educational facilities that might be required to support an educational environment designed to accommodate substantial individualization.

Chapter 11 provides a general description of the system software that needs to be developed to support a fully-fledged network-based learning system.

Chapter 12 discusses development of a large-scale system and concludes with an outline of a preliminary plan for building a network-based learning system capable of meeting educational requirements at an individual, school, district, regional, provincial/state, or national level.

Chapter 7

Developing the Curriculum for a Network-Based Learning System

Design Parameters for a Network-Based Learning System

The specifications that a learning system should meet were set forth in Chapter 6. The network-based learning system is defined as an instructional management system which meets those specifications by using a PERT-like network as the foundation for organizing a curriculum and for managing and supporting the entire instructional process -- in reality it is a computer-managed learning (CML) system with considerably more power than many CML systems in use today. The network-based learning system, like the Program Evaluation and Review Technique (PERT) from which it is derived, is generic and generalizable to any subject comprised of objectives that can be: (a) described, (b) measured, and (c) shown to have logical relationships to each other.

The network-based learning system supports the following activities: (a) organizing the curriculum, (b) monitoring student progress, (c) directing students to appropriate lessons and materials, (d) diagnosing and prescribing learning objectives, (e) evaluating student outcomes, (f) evaluating the curriculum, (g) evaluating teachers, (h) selecting test items from test banks, (i) managing learning resources, and (j) providing educational and curriculum planning information for educational managers at the classroom, school, district and provincial/state levels.

New learning systems must be more attractive than the systems they are to replace.

In addition, the network-based learning system has been designed to meet the cardinal rule for innovations and new systems -- it is simpler and easier to use than any other instructional methodology or learning system available. In that regard, clear cut benefits are included in the system for students, teachers, district administrators and provincial/state planners.

For students, the network-based learning system: (a) outlines the scope of programs and courses they will undertake and the criteria by which they will be evaluated; (b) provides access to a summary of achievement to date, provides direction or guidance in choosing subsequent learning objectives, aids selection of suitable learning resources in keeping with their learning styles and preferences, provides formative and summative tests of achievement based on the curriculum content being studied, and with immediate feedback of the results of performance on tests and lesson evaluations; (c) provides a description of the prerequisite skills required in any subsequent programs; (d) tests proficiency at pre-defined checkpoints throughout the curriculum; (e) provides review of acquired skills and proficiencies as necessary; (f) enables progress at individualized rates by using learning resources matched to abilities, aptitudes and learning styles; and, (g) highlights problem areas; and (h) facilitates direct one-on-one assistance from a teacher or instructional aide.

For teachers, the network-based learning system: (a) provides a graphic view of the scope and sequence of the curriculum and the criteria by which student mastery will be assessed; (b) reduces the work involved in constructing, issuing and marking tests and recording the results -- the management system performs these functions; (c) provides snapshots of students' progress on a regular or irregular basis; (d) maximizes interaction with students on a one-on-one basis and enables provision of additional assistance to those students who are progressing at a rate which is slower than expected; (e) focuses help and resources for students engaged in program and career planning; (f) assesses the achievement of students on materials already covered but which serve as a prerequisite for the learning objectives to be undertaken; (g) provides access to student and teacher resources and professional development materials congruent with the curriculum; and, (h) provides access to up-to-date curriculum evaluation data so that problems with the curriculum and learning resources may be quickly corrected.

For administrators and managers at the school, district, state or provincial levels, the network-based learning system allows them to: (a) access student achievement results (individually, or by groups) at any time; (b) employ a planning framework into which the work of many participants can be incorporated into a significant whole; (c) reduce major discrepancies in program interpretation in both student expectations and evaluation criteria; (d) describe the program and learning resources to the public or other interested stakeholders; and, (e) to "tailor" courses and programs for individual students which are not necessarily bound to specific sites (i.e., classrooms) or to specific times (i.e., during regular class periods).

A further attribute of the network-based learning system is a feature which encourages and facilitates cooperation among a number of different groups and specializations in activities leading to development of a curriculum -- specialties such as teachers, child development specialists, learning psychologists, curriculum writers, illustrators, and others.

For the network-based learning system manager, the system provides: (a) an authoring system that guides development of the curriculum and related resources; (b) feedback on the efficiency and effectiveness of the curriculum design and implementation modes; (c) mechanisms for highlighting problem areas; and, (d) mechanisms for maintaining the curriculum at the highest possible state of currency and quality.

A Curriculum Development Framework

A curriculum development framework focuses attention on critical variables.

Figure 17 displays the curriculum development framework around which network-based curriculum methodology has been built. The framework contains nine components, each requiring attention during the curriculum development phase of the network-base learning system design: (a) determining the nature and learning needs of clients and describing those needs in the form of objectives or goals; (b) setting specific program (curriculum) objectives; (c) describing the nature and logic of the body of knowledge under consideration; (d) selecting the curriculum content, (e) organizing the curriculum content; (f) accommodating the nature and needs of the learner; (g) accommodating learning theory and instructional methods into the instructional design; (h) evaluating both students and the curriculum; and (i) providing feedback.

This curriculum development framework may be translated into a curriculum through a relatively simple process. Learning needs of students are first assessed and then translated into a set of broad aims and objectives. To meet these aims and objectives, and based on the nature of the learners, appropriate curriculum content is selected and organized -- the scope and sequence of the curriculum are established. Based on individual differences present within the learner population, a set of instructional materials and alternatives is prepared. Implementation of the developed curriculum entails leading each individual learner through the scope and sequence of the curriculum at their own pace by using the most appropriate learning theories and instructional materials. Evaluative data pertaining to both the curriculum and the learners' progress are collected and analyzed with the resulting feedback used to revise the scope and sequence of the curriculum, the instructional materials, and/or the progress and direction of the learner.

The focus of this chapter now shifts to consideration of how the elements of the framework may be incorporated into the design of a learning system capable of providing, among other things, a way of managing individualized instruction or independent learning.

Steps in Development of a Network-Based Curriculum

Development, implementation and evaluation of a network-based curriculum may be achieved by following ten steps (Hathaway, in press).

Step 1. Identify the educational needs to be met and state the broad aims and objectives to be achieved. These aims and objectives may describe a single course, a set of courses, an entire program, or a set of programs.

Step 2. In turn, treat each of the broad aims and objectives as terminal objectives and analyze them in hierarchical fashion to

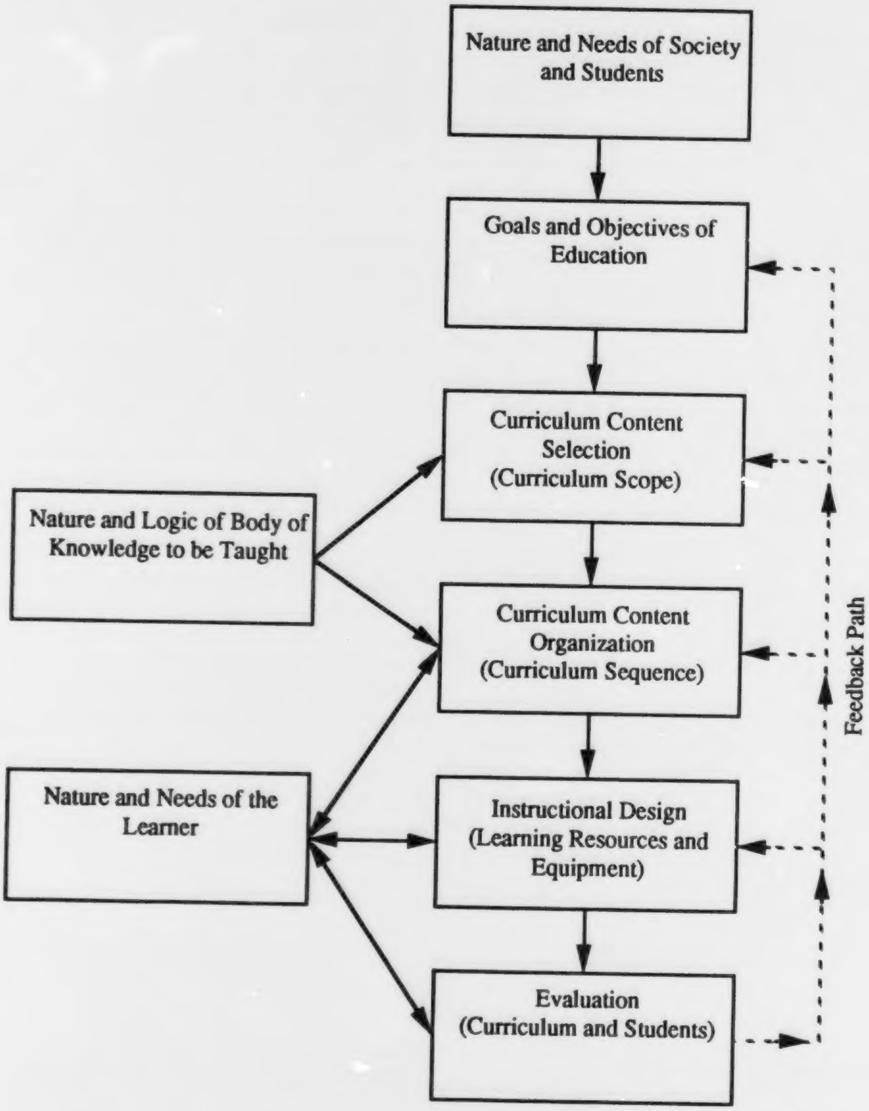

Nature and Needs of Society and Students
Goals and Objectives of Education
Curriculum Content Selection (Curriculum Scope)
Nature and Logic of Body of Knowledge to be Taught
Curriculum Content Organization (Curriculum Sequence)
Feedback Path
Nature and Needs of the Learner
Instructional Design (Learning Resources and Equipment)
Evaluation (Curriculum and Students)

Figure 17. A curriculum development model.

identify the enabling objectives required to achieve them (refer to Figure 8 for further clarification of this process). The process of subdivision may be repeated, as often as necessary, by regarding each new enabling objective as a terminal objective and further analyzing it for its enabling objectives. Continue subdividing the objectives until the entire set of detailed objectives has been identified. A worksheet of the type shown in Figure 18 simplifies the task of analyzing and subdividing objectives.

For the sake of clarity in subsequent discussions, the different levels of objectives are given names and classified as follows:

- Program Objectives
- Course Objectives (several per program)
- Unit Objectives (10 to 20 per course)
- Lesson Objectives (10 to 30 per unit)
- Learning Steps or Concepts (from four or five to one hundred or more per lesson). The scope and sequence of the learning steps constitutes the strategy to be used in developing students' understandings of the lesson.

Objectives are organized into networks.

Step 3. Identify the course objectives within programs and the unit objectives within each course (Figure 18) and arrange the objectives at each level into a network reflecting the most appropriate sequencing. The nature and logic of the knowledge content of the curriculum should be considered when relating units to each other. An example of a network of units (referred to as a Course Summary Network) is shown in Figure 19.

Step 4. Continue the breakdown or subdivision of objectives started in Steps 2 and 3 by identifying the lesson objectives (or topics) required to complete each unit (identified in the right hand column of Figure 18).

Completion of a lesson by a student may be regarded as a rewarding experience -- a success. Consequently, the number of lesson objectives required to achieve success in a unit, and subsequently a course or a program, is a decision that teachers and curriculum planners engaged in curriculum development must make as they consider the optimum frequency of successes students require in order to maintain high motivation in the course. Obviously, the decision is a complex one and based, in part, on the attitude of the learner, the age of the learner, and the subject material. A simple rule-of-thumb suggests that lessons, on average, should be designed for completion in less than one or two class periods of work (i.e., about two hours or less). Any necessary adjustments can be made around this figure. Unit objectives comprised of sets of lesson objectives, are achieved over longer periods of time, perhaps four to eight weeks, with several units comprising a year-long course.

In the same way that the units were arranged into a Course Network in Step 3, arrange the lesson objectives comprising each unit into a network. The organization of the detailed Unit Networks also take into consideration the nature of the body of knowledge to be taught as well as child development and readiness theory, and learning theory. Optimizing these variables is the goal of this step. Figure 20 is an example of the Unit Network of lessons selected to achieve the "Basic Electricity" unit identified in Figure 19.

Course Objective

Science 11

The students will understand and apply the basic relationships encountered in the fields of physics, biology, chemistry and mathematics to daily activities. Students will apply the "scientific method" to everyday problems.

Unit Objectives	Lesson Topic
Basic Electricity The student will: identify applications of physics, chemistry and mathematics in studies of electricity; demonstrate a correct usage of basic electrical terms; select and correctly use electrical measuring devices in laboratory situations; safely and correctly assemble test circuits; and perform simple circuit parameter calculations based on applications of Ohm's Law.	• Electrical terms • Sources of electricity • Measuring devices • Chemical energy • Batteries • Magnetism • DC electricity • AC electricity • Electrical safety • Ohm's Law • Series and parallel circuits
Basic Mechanics The student will become familiar with the basic concepts of mechanics and will be able to relate them to daily activities both inside and outside the classroom laboratory. Emphasis will be on: work, friction, and the relationships between them.	• Linear measurement • Energy • Work • Force • Power • Etc.
Other Units ...	• Etc.

Figure 18. A Course breakdown framework and worksheet.

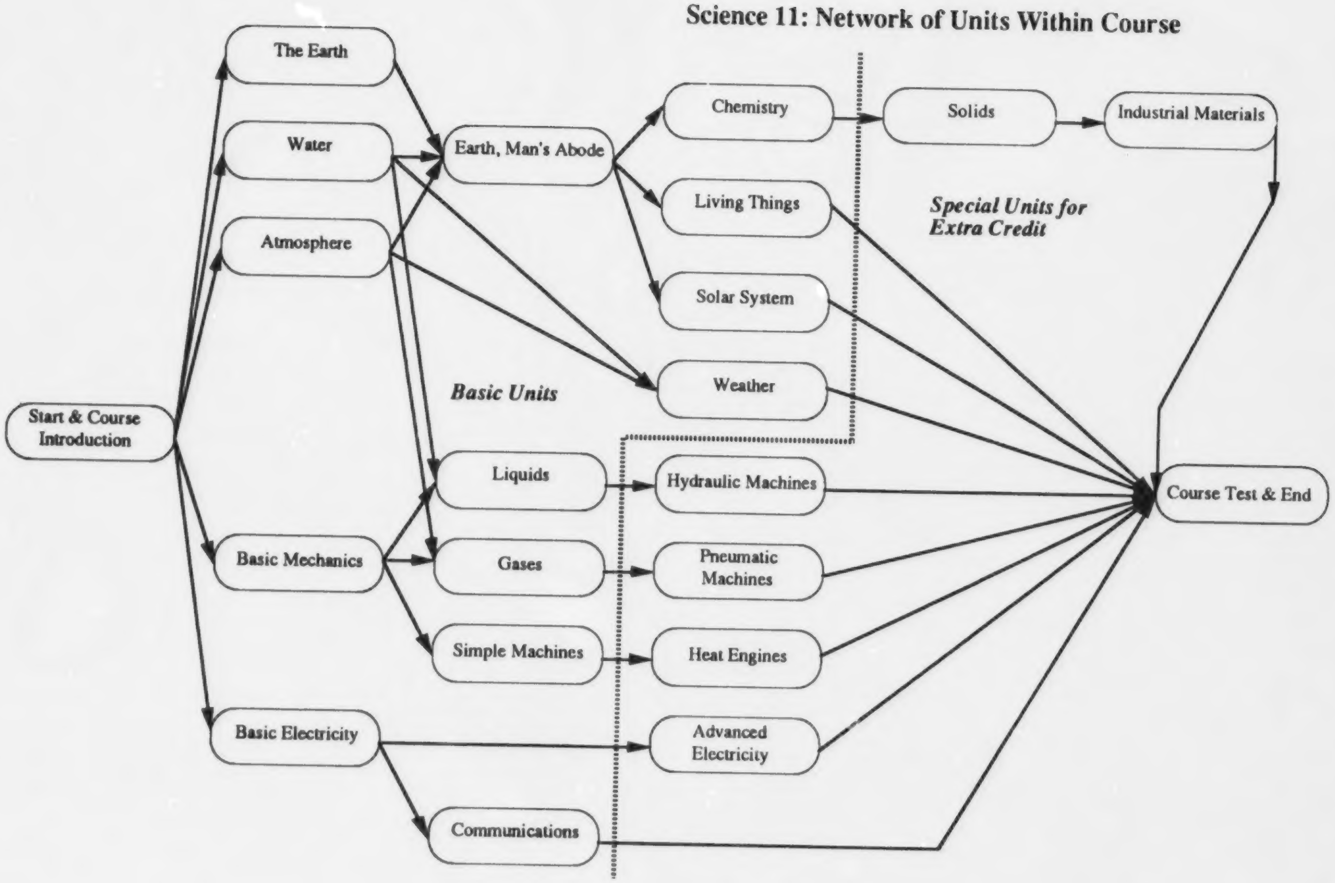

Science 11: Network of Units Within Course
Start & Course Introduction
The Earth
Water
Atmosphere
Basic Mechanics
Basic Electricity
Earth, Man's Abode
Basic Units
Liquids
Gases
Simple Machines
Communications
Chemistry
Living Things
Solar System
Weather
Hydraulic Machines
Pneumatic Machines
Heat Engines
Advanced Electricity
Solids
Industrial Materials
Special Units for Extra Credit
Course Test & End

Figure 19. A network of units comprising a Science Course: A Course Summary Network.

Basic Electricity (Detailed Lesson Network)

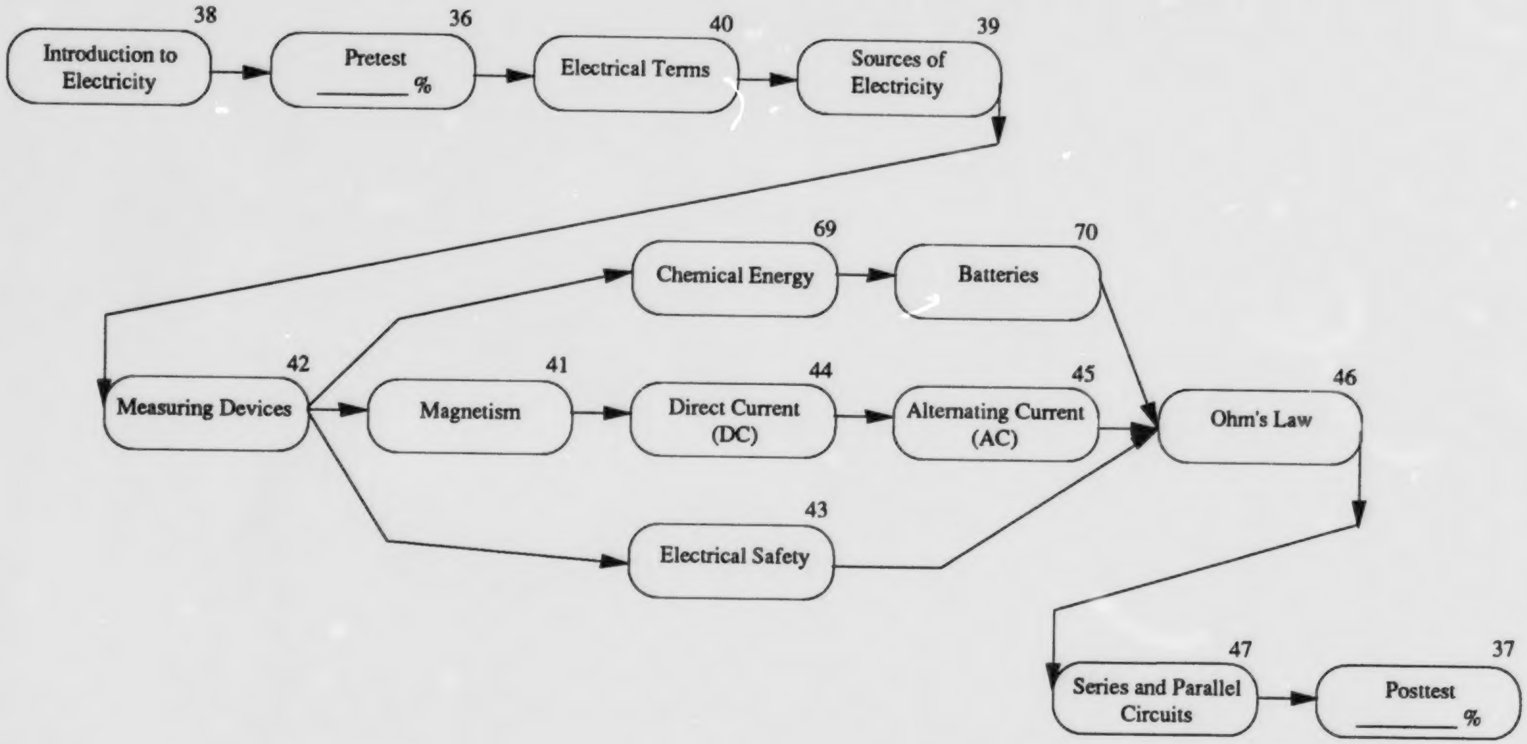
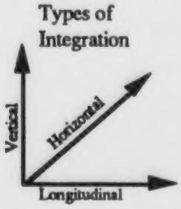
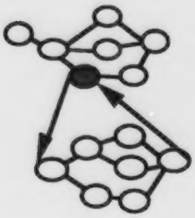

38
Introduction to Electricity
36
Pretest
_______ %
40
Electrical Terms
39
Sources of Electricity
69
Chemical Energy
70
Batteries
42
Measuring Devices
41
Magnetism
44
Direct Current (DC)
45
Alternating Current (AC)
46
Ohm's Law
43
Electrical Safety
47
Series and Parallel Circuits
37
Posttest
_______ %

Figure 20. A network of lesson objectives to be achieved in the Basic Science Unit.



Some of the power of network-based learning systems lies in the nesting or telescoping relationships of lesson, unit, course and program objectives. The network-based learning system is amenable to complete vertical, longitudinal, and horizontal integration. Vertical integration means that every objective below the top level nests into some other higher-order objective. Longitudinal integration means that the curriculum sequencing can have a high degree of integrity. Every objective, at all levels, has both predecessor and successor objectives (except the starting and ending objectives in a program). No objectives will be found in a longitudinally integrated network that do not have both predecessor and successor objectives. Horizontal integration (shown in Figure 21) describes the capability for linking objectives on parallel networks in a logical fashion. For example, predecessor mathematics objectives must precede certain science objectives where those mathematics concepts might be applied. The network-based learning system also makes it possible to include course, unit, and lesson alternatives designed to accommodate individual student differences.



Step 5. With lessons identified within each unit included in the Course Network, the Unit Networks should be arranged on a work surface in rough correspondence to the position of the unit "bubbles" in the Course Network.

Using this arrangement of Unit Networks as a guide, a detailed course or master network may be prepared -- by hand if a manual approach is being followed or by computer if an automated system is available. In the manual mode, this requires the use of a large piece of tracing paper of the type used by draftsmen, since this permits reproduction of the drawings in blueprint form. Drafting paper is usually available in widths from thirty to forty-two inches and a typical course network may required fifteen to thirty square feet of this paper. In the automated mode, a computer-driven plotter would be utilized.

Depicting the scope, sequence, and interrelationships in a set of lesson objectives comprising a course, or sequence of courses, in a single master network enables the teacher and others to evaluate the program, to identify gaps and redundancies, to analyze the total set of interrelationships among the lesson objectives, and to plan instructional strategies. It enables teachers to make the same sorts of judgements about the curriculum as those made by a traveller planning a trip route by looking at a large road map.

Evaluation of the initial network may lead to revision and re-drawing of the network, however, the increased quality is well worth the added effort. In one case, almost one-quarter of an elementary mathematics curriculum was substantially revised because of redundancy or because some concepts were found which did not have either the necessary predecessor activities or the necessary successor activities. Concepts were being presented without any sort of a context.

A note of caution must be interjected at this point. Because network analysis is a powerful evaluative tool, teachers and educational planners may become bogged down with trying to develop a "perfect" network. The best strategy is to develop an "acceptable" network and then hasten to implement it. An "acceptable" network is one that appears to be logical and free from obvious faults. All of the objectives organized as sequences are clearly interdependent and best achieved in the specified

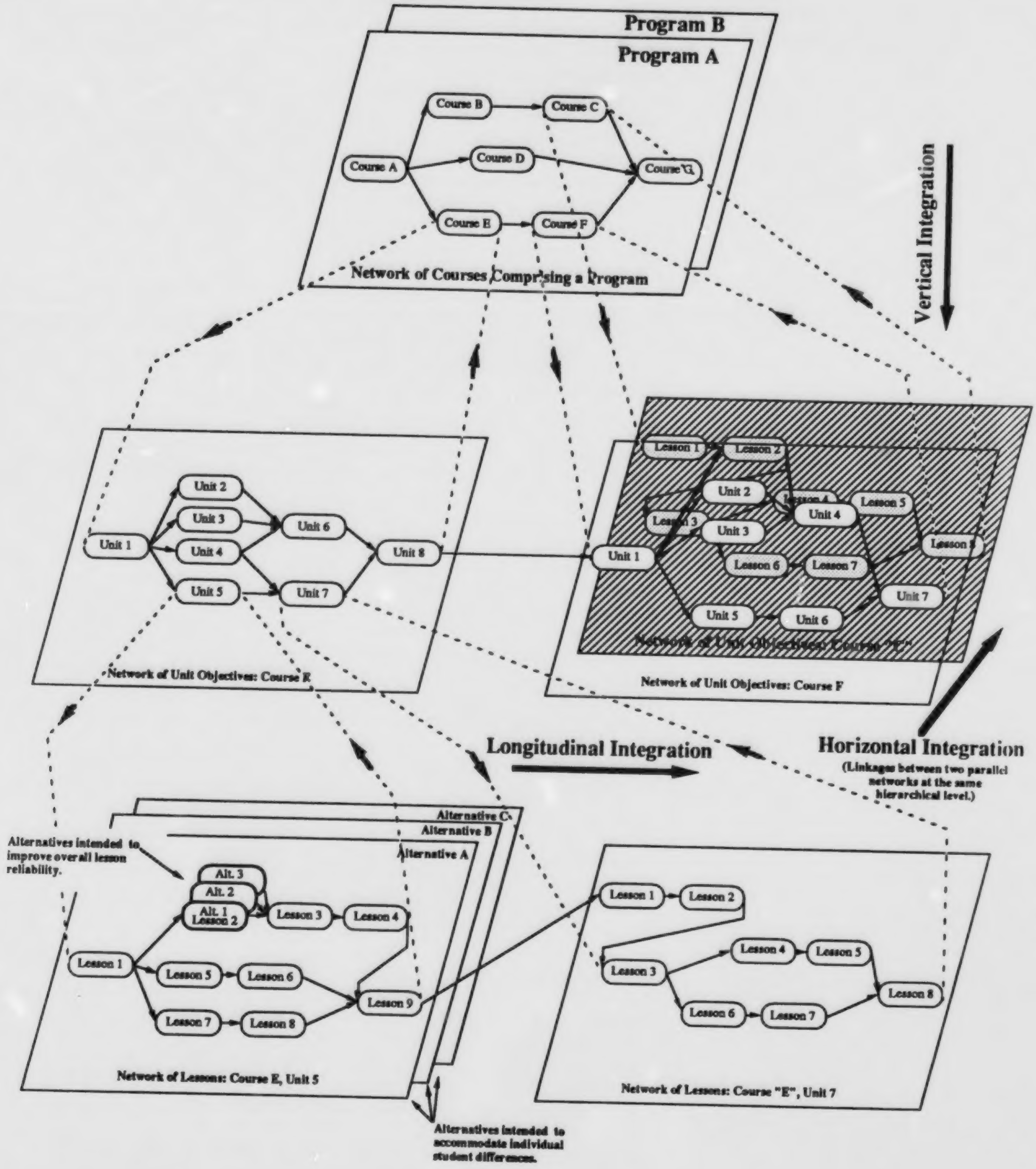

Program B
Program A
Course A
Course B
Course C
Course D
Course G
Course E
Course F
Network of Courses Comprising a Program
Vertical Integration
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 6
Unit 7
Unit 8
Network of Unit Objectives: Course E
Lesson 1
Lesson 2
Lesson 3
Lesson 4
Lesson 5
Lesson 6
Lesson 7
Lesson 8
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 6
Unit 7
Network of Unit Objectives: Course "E"
Network of Unit Objectives: Course F
Longitudinal Integration
Horizontal Integration
(Linkages between two parallel networks at the same hierarchical level.)
Alternative C
Alternative B
Alternative A
Alternatives intended to improve overall lesson reliability.
Alt. 3
Alt. 2
Alt. 1
Lesson 2
Lesson 1
Lesson 3
Lesson 4
Lesson 5
Lesson 6
Lesson 7
Lesson 8
Lesson 9
Network of Lessons: Course E, Unit 5
Alternatives intended to accommodate individual student differences.
Lesson 1
Lesson 2
Lesson 3
Lesson 4
Lesson 5
Lesson 6
Lesson 7
Lesson 8
Network of Lessons: Course "E", Unit 7

Figure 21. Vertical, horizontal and longitudinal integration capabilities of the networking technique.

sequence. All of the objectives arranged in parallel have no clearly defined interdependencies and may be pursued in any order. Moreover, the network should appear rational when regarded from the vantage points of the learning theorist, the developmental theorist, the subject specialist, the teacher, and the student. Starting with an acceptable network, experience will provide the clearest insights into the optimum patterns of objective organization and the need for revisions.

Networks provide graphic "advance organizers".

A well designed curriculum network offers tremendous advantages for students -- especially in the area of concept formulation. The curriculum in the form in which it is most often found today is a somewhat amorphous mass. Individual teachers present parts of the curriculum to students who have the task of understanding the curriculum. To do this students must learn to organize information into conceptualizations. Networks make it possible to transform an amorphous curriculum into a curriculum with substantial form. For students, the form and structure of the curriculum facilitates the formulation of conceptualizations. Indeed, networks serve as advance organizers of information and advance organizers were identified as important aids to learning by Ausubel (1965: 111).

Step 6. When the Master Network has been deemed to be acceptable, numbers should be assigned to each lesson objective on the network. Do not assign the same number twice and do not try to follow a particular numbering sequence. After the master network has been numbered, these numbers should be transferred to the corresponding lesson objectives on the Unit Networks (Figure 20). It should be noted here that numbers are assigned only to lesson objectives on the Unit Networks and not to unit objectives on the Course Summary Network, although the Unit and Course Networks should be assigned meaningful names or alphanumeric designations to make identification easier.

A copy of the completed Master Network makes an excellent classroom wall display since it gives students a notion of what the course contains -- it serves as an excellent "advance organizer" by providing a comprehensive overview. As will be shown later, the numbered Master Network and the Unit Networks also serve as the key to location of all filed learning resources and equipment.

Lesson Outlines serve as effective and efficient lesson plans.

Step 7. To facilitate subsequent planning, a Lesson Outline should be developed for each lesson objective contained in the Master Network. Several important items should be recorded on the Lesson Outline as shown in Figure 22.

a. Record the lesson objective number. These numbers, taken from the networks, serve as access codes to any instructional materials, reference materials or resource materials stored in numerical sequence. Regardless of the method of course implementation, filed materials should always include an up-to-date set of Lesson Outlines.

b. State the title or topic of the lesson. Often the brief description contained in the network "bubbles" is adequate.

c. State the objective of the lesson in performance terms. Ideally, the objective should indicate as specifically as possible: the student performance to be observed after instruction; the extent to which the performance will be displayed; and, the conditions under which the performance is to be observed or demonstrated. An example of an

Lesson Topic: Series and Parallel Circuits **Lesson Activity Time:** (in periods of instruction) a = 1.0, m = 3.0, b = 6.0, t_e = 3.2, sd = 0.8, q = 0.25	**Lesson Number:** 47 **Network Name:** Science 11

Lesson Objective

The student will, to the instructor's satisfaction: identify series and parallel laboratory demonstration circuits and/or schematic drawings; point out basic similarities and differences on the demonstration circuits or schematic diagrams; state how each of the circuits is to be recognized; identify problems that may occur when circuits are incorrectly used; and perform DC voltage, current and power tests and measurements on series and parallel demonstration circuits.

Lesson Outline

Lesson Content to be Covered	**Resource Materials**
Meaning of a "parallel" circuit	Lesson text
Meaning of a "series" circuit	Lesson text
Processes to be Developed	
Measure parallel circuit parameteers	Demonstration Board #47
Measure series circuit parameters	Demonstration Board #47
Analyze observations and generalize into a set of rules	
Apply concepts in a practical situation	Instructor selects situation

Remarks	**Materials and Equipment**
	· Battery charger · Demo Board #47 · DC Ammeter · DC Voltmeter · Light bulbs, 12V, 25W · Test leads and hook-up wire

Figure 22. A lesson outlining and record-keeping form.

acceptable objective statement may be found on the Lesson Outline shown in Figure 22.

Networks may be developed around different kinds of objectives.

As the objectives are being developed, a number of parameters should be attended to by the learning system planner. For classroom teachers working with relatively homogeneous groups of students, the number of parameters to be addressed may be modest in number. For large curriculum development projects aimed at preparing programs for implementation in heterogeneous groups, a wide variety of objective types may be incorporated into the network-based learning system. The following are some of the objective groups and types that may be encountered and included in a curriculum network: (a) experiential, performance, behavioral; (b) knowledge-based, skill-oriented; (c) cooperative, competitive; (d) individual, small group, large group; (e) cognitive, affective, psychomotor (taxonomies are available which subdivide and describe these objectives in detail, for example Bloom's (Bloom, et al, 1956) and Krathwohl's (Krathwohl, 1968) taxonomies); (f) acquisition, assimilation, review; and, (g) objectives arranged from either general to specific or from specific to general.

It is also important to remember that evaluation should be compatible with the nature of the objective. For example, individuals should be evaluated only on objectives suited for individual achievement and over which the individual has control. By the same token, individual students should not be failed on group objectives. The group passes or fails as a group -- not as individual members.

d. Identify the new content to be introduced in the lesson.

e. Identify the processes that must be developed or reinforced by the lesson.

f. Note all available learning resource materials and audio-visual aids.

g. Identify and record material and equipment requirements. Resources may also include personnel and facilities. Aggregations of lesson development and implementation costs by units, courses, or programs provide a basis for budgeting which is both precise and totally compatible with any of the Planning, Programming, Budgeting, Evaluation System (PPBES) models. The present state-of-the-art is such that few PPBES models are able to use such detailed data. Having this detailed information readily available would, however, place teachers in the enviable position of being able to specify appropriate interfaces between PPBES models and classroom planning.

Student records and learning resource management are linked.

Step 8. Using the Lesson Outlines as guides, instructional strategies for achieving lesson objectives may be developed. Lessons will most often be implemented in one of two ways: either the teacher will be the source of information or the source of information (the learning resource) will be a media package. In this latter case, two aspects deserve attention -- (a) the learning resources themselves and (b) the system which keeps records of student progress and points them to needed resources.

Variety in media packages may be as wide-ranging as the teacher may choose. While there is great variety in the types of media packages that are already developed or that may be developed, the range of media types that should be selected and used is much narrower.

Print materials (i.e., text books), audio tapes, video tapes, broadcasts, and many computer programs are linear or sequential devices. With the exception of print materials, learning resources in these other forms cannot be scanned or reviewed easily: the media formats demand that users proceed from beginning to end, and often at a slow and ponderous pace. This is contrary to what many people like to do -- they like to browse and scan to locate information of interest or relevance.

Learning resources should be designed and developed to support as many features as possible that help students: features that permit browsing, scanning, reviewing, and perhaps even marking and making notations. Beyond print media, only interactive video discs appear to have these features.

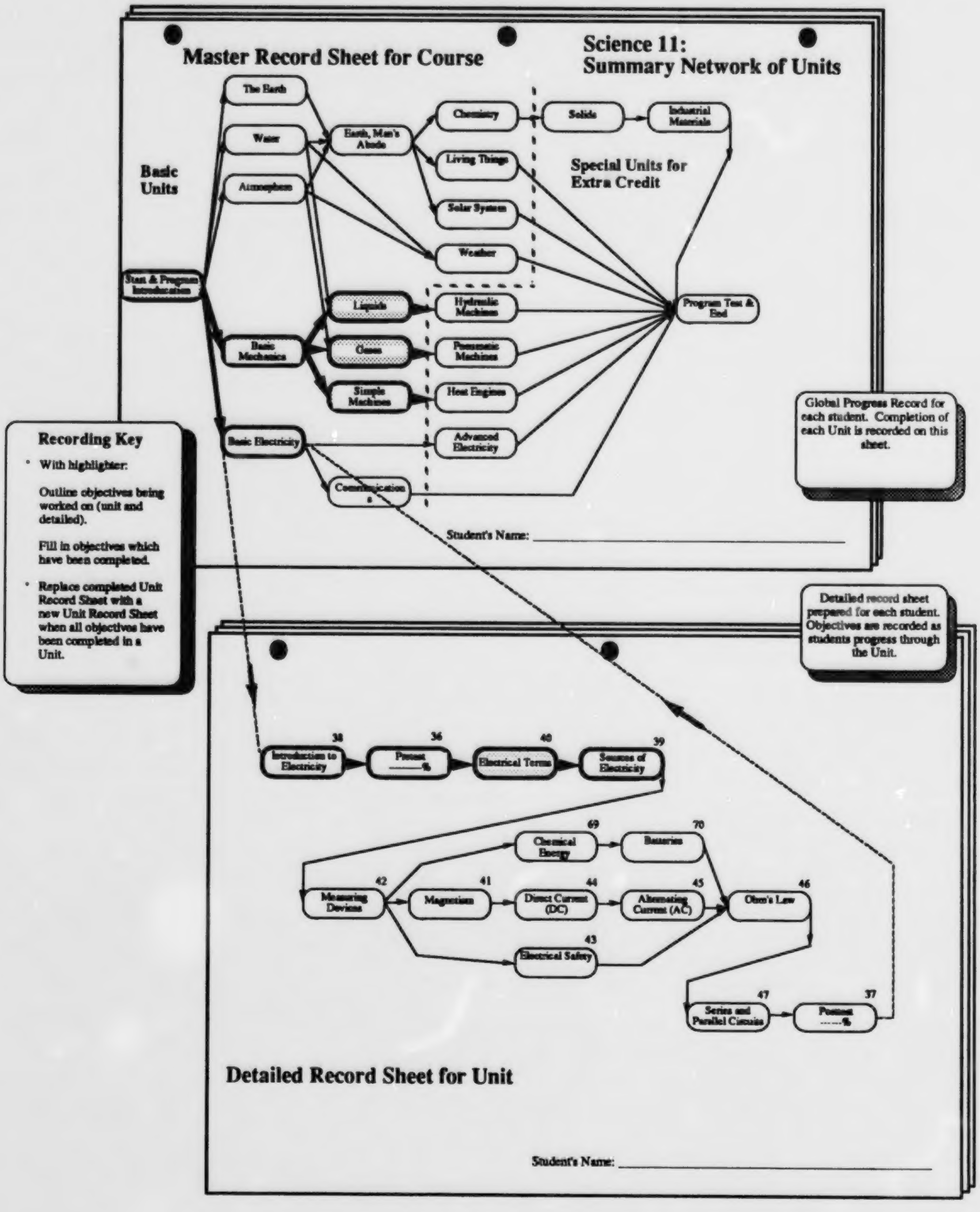
One of the purposes for developing a network-based curriculum is to facilitate individualized learning. A drawback with many of the contemporary approaches to individualization is the failure to provide a simple and foolproof method for recording student progress. In this approach a Course Network (Figure 19) and the appropriate detailed Unit Networks (an example is shown in Figure 20) serve as student record sheets and are prepared and maintained for each student, thereby providing a means of checking both global progress in a course or program and detailed progress in appropriate units of study. Figure 23 shows how the Course Network and the Detailed Unit Networks are linked together to provide a graphic macro-detail and a micro-detail record-keeping system. The Detailed Unit Networks also contain an identification code which serves as a key to accessing learning resources.

A loose-leaf file made up of these student record sheets, and a library of numerically filed lessons and instructional aids, enables students to learn and to progress at their own rates with a minimum of interruption to other students working either ahead or behind them. This feature is especially vital if attendance patterns are irregular because of work experience programs, illness, or for countless other reasons.

Evaluation of lessons is reduced to GO/NO GO decisions.

Evaluation of each lesson objective, as the precision of preparing objectives increases, approaches a GO/NO GO decision -- either the student has mastered the objective or the student has not. When the student has met the criteria for a particular objective, notation is made on the student's Unit Network. When all of the objectives on the Unit Network have been completed, notation is made on the students' Course Network. At the same time the completed Unit Network is discarded and a different Unit Network is selected and put in its place, there to guide the student through another set of learning experiences identified in the Course Network.

Step 9. Evaluation of both the program and the students' progress may be facilitated by using data describing the elapsed activity or completion time for each lesson.


Master Record Sheet for Course
Science 11:
Summary Network of Units
Basic Units
Start & Program Introduction
The Earth
Water
Atmosphere
Earth, Man's Abode
Chemistry
Living Things
Solar System
Weather
Solids
Industrial Materials
Special Units for Extra Credit
Basic Mechanics
Liquids
Gases
Simple Machines
Hydraulic Machines
Pneumatic Machines
Heat Engines
Basic Electricity
Advanced Electricity
Communications
Program Test & End
Student's Name:
38
Introduction to Electricity
36
Pretest ——%
40
Electrical Terms
39
Sources of Electricity
42
Measuring Devices
69
Chemical Energy
70
Batteries
41
Magnetism
44
Direct Current (DC)
45
Alternating Current (AC)
46
Ohm's Law
43
Electrical Safety
47
Series and Parallel Circuits
37
Posttest ——%
Detailed Record Sheet for Unit
Student's Name:

Recording Key

- With highlighter:

  Outline objectives being worked on (unit and detailed).

  Fill in objectives which have been completed.

- Replace completed Unit Record Sheet with a new Unit Record Sheet when all objectives have been completed in a Unit.

Global Progress Record for each student. Completion of each Unit is recorded on this sheet.

Detailed record sheet prepared for each student. Objectives are recorded as students progress through the Unit.

Figure 23. An individualized student record-keeping system.

As the curriculum is being developed, approximate lesson activity times may be estimated by teachers on the basis of experience. However, not all students will complete lessons in the same length of time in individualized programs. As the program is implemented, a tally sheet of actual activity times may be compiled in order to determine more accurately the differences in completion times for each lesson objective*. These collected data are periodically analyzed in order to obtain evaluative data pertaining to both the students and the program and with both based on students' performance. Analysis of student records can, for example, provide statistics describing the average length of time required to complete each lesson or objective. This information aids development of courses which are appropriately and uniformly weighted. Because this information is not available during the initial course design phase, a method of estimating these characteristics is offered below.

a. The average completion time for lessons may be calculated in two ways: on the basis of student performance with the lessons (as evidenced by collected statistical information) or by estimating the expected average completion time. The formula for estimating the average completion time for each objective is:

$$t_e = \frac{a + 4m + b}{6}$$

where: t_e is the average length of time to complete the objective; *a* is the shortest time required to complete the objective; *m* is the most frequently required time to complete the objective; and *b* is the longest time required to complete the objective.

The expected time to complete the activity (t_e) has a probability of 0.5 (a 50-50 chance) of being completed on, or ahead of, schedule.

b. The standard deviation (*sd*) of time estimates may be calculated by using the collected statistics from (a) above or it may be estimated or approximated by using:

$$sd = \frac{b - a}{6}$$

Approximately sixty eight percent of the students will complete each objective within $t_e \pm 1$ *sd* units of time.

c. An uncertainty factor or *q factor* (lesson unreliability factor) for each lesson may be calculated by using the following formula (Hathaway, 1977):

---

* When a computer is available to manage the network-based curriculum, it is quite feasible to program it to capture historical information describing student performance on lessons. These data may be analyzed and average lesson completion times, standard deviations of these times, and lesson quality indicators calculated and reported regularly.

$$q = \frac{sd}{t_e}$$

Rank ordering of all lessons in terms of the *q factor* ensures that the worst lessons systematically receive first attention when time becomes available for curriculum revision. A high *q factor* indicates a poor lesson, and a low *q factor* indicates a good lesson. When questionable lessons are identified, attempts should be made to revise and improve them as quickly as possible.

All of the calculations completed so far should be recorded in the appropriate spaces on the Lesson Outline as shown in Figure 22.

Figure 24 provides an opportunity to digress for a moment and to illustrate how the curriculum may be improved through use of evaluative statistics. Figure 24b depicts a portion of a Mechanics Unit in which Lesson 17 (Inclined Plane) was found to be of low quality -- even confusing to some students.

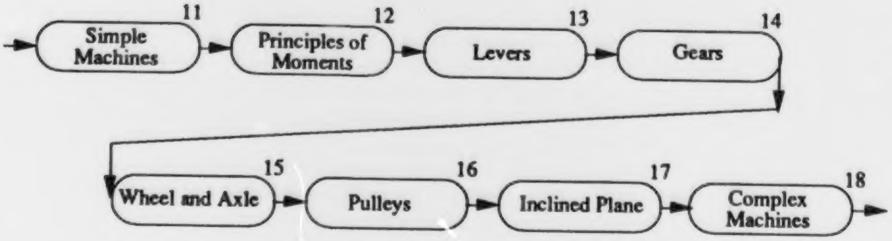
Traditionally, non-learning has been attributed to poor and inattentive students -- seldom the curriculum.

In the network-based learning system, curriculum defects are highlighted for attention.

Someone with a modest knowledge of mechanical principles will immediately spot the problem: the "inclined plane" has little in common with Objectives 12 - 15 (Figure 24b). When the network was reorganized as shown in Figure 24c, the lesson problems were resolved. The lesson didn't even need much additional revision. The lesson to be learned is this: textual material or classroom instruction often follows a linear sequence with the result that concepts are presented as 11, 12, 13, 14, 15, 16, 17, and 18 as shown in Figure 24a. The problem is that the brain handles verbal communication (speaking and listening) only in sequential fashion with the result that it is difficult to deal with complex conceptual relationships. Pictures make it possible for the brain to process concurrently both visual and auditory messages and this characteristic permits teachers to present more complex messages to students. Accordingly, the relationships or structure of the concepts shown in Figures 24b and 24c helps students organize the information in their minds. The modification of the logic structure (as described in Figure 24c) conveyed a different message to students from that in Figure 24b -- Lesson 17 (the inclined plane) as well as Lesson 16 (pulleys) should be examined both for their similarities to, and their differences from, other simple machines. Only systematic evaluation of a highly structured curriculum can pinpoint these types of problems. All too often traditional styles of classroom instruction are not revised (because they are not carefully organized and they are encountered only once each year (or semester). Any faults for non-learning are generally attributed to poor students -- never to the curriculum or the instructional presentation.

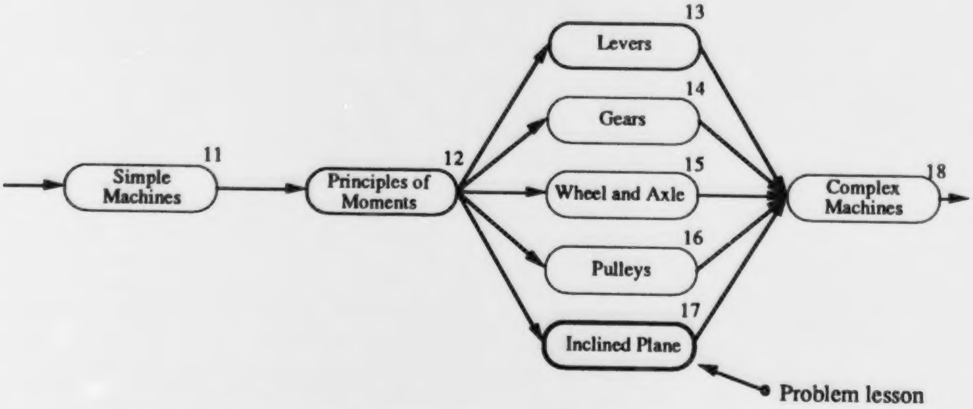
d. Carnegie Units or Credit equivalencies may be calculated by summing the average activity times (t_es) for all of the objectives completed by a student. The student has earned the equivalent of a Carnegie Unit when the sum of the activity times for a set of completed objectives (Σt_es) totals a specified number of hours. Though average students will earn a Carnegie Unit in a period approximately equal to the specified number of hours, others may require more or less time. Completed objectives, and not time spent in class, becomes the basis for assignment of credits.

Step 10. By using Pre-test and Post-test statistics for each unit of instruction, it is also possible to assess the overall effectiveness of a



11
Simple Machines
12
Principles of Moments
13
Levers
14
Gears
15
Wheel and Axle
16
Pulleys
17
Inclined Plane
18
Complex Machines

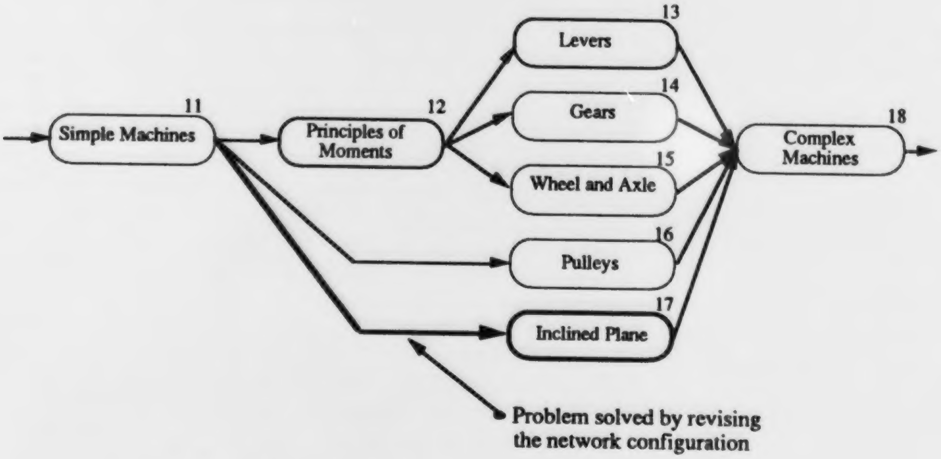
Figure 24a. Linear logic characteristic of most classroom instruction. Opportunities for evalation occur once per term or semester. Non-learning is often attributed to poor and inattentive students.



13
Levers
14
Gears
11
Simple Machines
12
Principles of Moments
15
Wheel and Axle
18
Complex Machines
16
Pulleys
17
Inclined Plane

Problem lesson

Figure 24b. Networks provide graphic advance organizers for the curriculum. Evaluation serves to pinpoint problems in the curriculum.



13
Levers
14
Gears
11
Simple Machines
12
Principles of Moments
18
Complex Machines
15
Wheel and Axle
16
Pulleys
17
Inclined Plane

Problem solved by revising the network configuration

Figure 24c. Network configuration following evaluation and revision.

Figure 24. Revising the network-based curriculum.

total unit or course of instruction. This information is easily obtained through a computer analysis of machine-scored test answer sheets. Such a comparison is show in Figure 25. This information makes it possible to rank-order units in terms of their pedagogical strength.

Summary

By following the ten steps outlined in this chapter, the educator has: (a) a mapping of the curriculum which displays all of the objectives and their interrelationships, (b) a set of lesson outlines (one for each lesson or objective) with the content, processes, and resources identified, and (c) a framework for evaluating both students and the the material comprising the curriculum. For the classroom teacher choosing to implement the curriculum in traditional ways, the curriculum mapping and the set of lesson outlines can be used as a comprehensive and integrated set of lesson plans.

Subsequent chapters explain how the network-based curriculum may be implemented in a variety of settings.

Basic Electricity (Detailed Lesson Network)

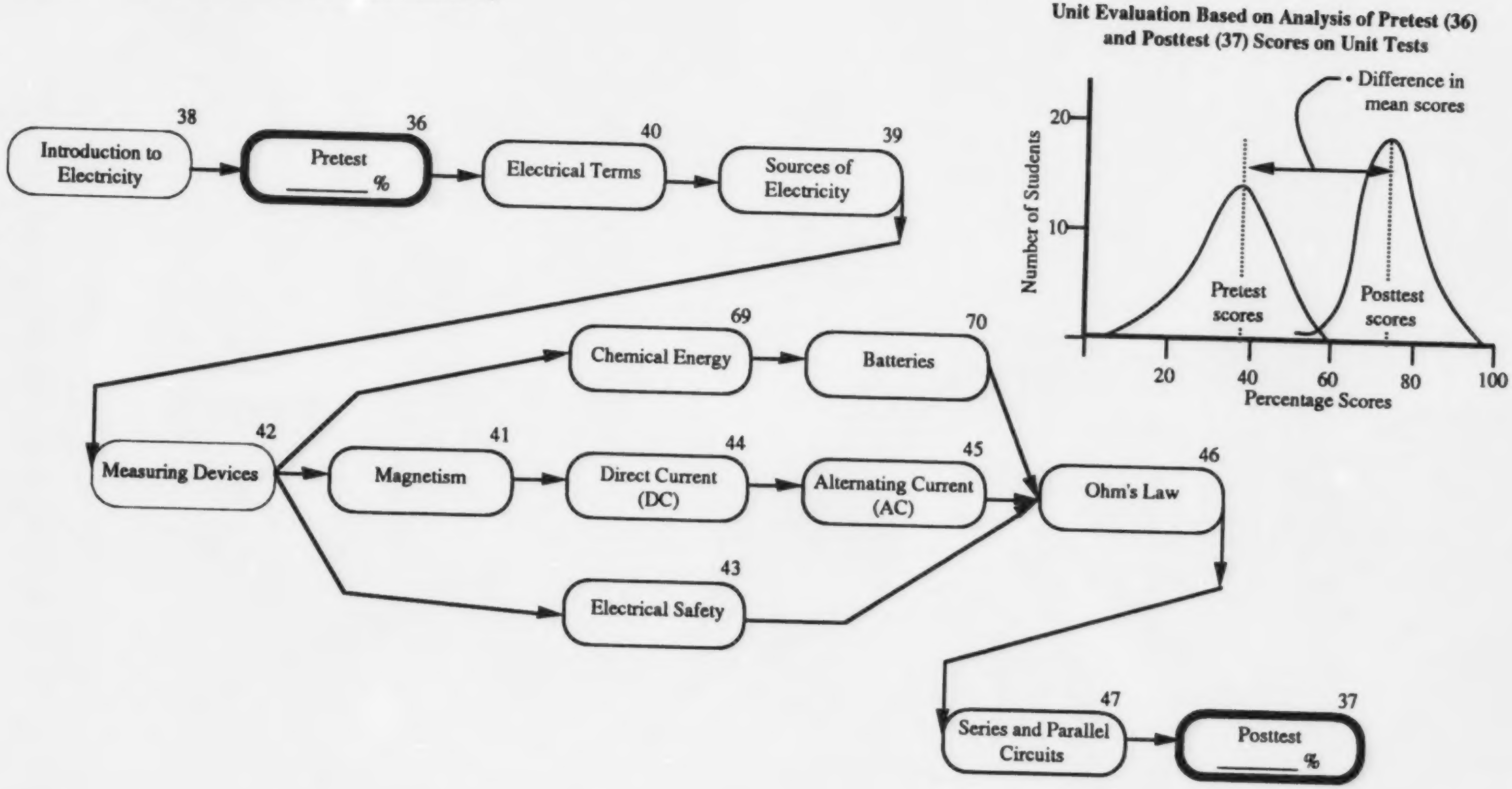

38
Introduction to Electricity
36
Pretest
_______ %
40
Electrical Terms
39
Sources of Electricity
42
Measuring Devices
69
Chemical Energy
70
Batteries
41
Magnetism
44
Direct Current (DC)
45
Alternating Current (AC)
46
Ohm's Law
43
Electrical Safety
47
Series and Parallel Circuits
37
Posttest
_______ %
Unit Evaluation Based on Analysis of Pretest (36) and Posttest (37) Scores on Unit Tests
• Difference in mean scores
Number of Students
20
10
Pretest scores
Posttest scores
20
40
60
80
100
Percentage Scores

Figure 25. A method for displaying evaluation information relating to units of instruction.

Chapter 8

Implementing the Network-Based Learning System

The network-based curriculum may be implemented:
- *in regular classrooms*
- *by teams of teachers*
- *in a department*
- *through service centers*
- *independently by students.*

Once the curriculum networks, lesson outlines, and learning resources have been developed, there are at least three ways by which the network-based learning system may be implemented in classrooms: (a) on an individualized basis, (b) with small groups, and (c) with large groups (or in combinations of these). In addition, the network-based learning system may be implemented in a number of different contexts. One is the traditional approach wherein an instructor uses the curriculum network as a guide for presenting material to groups or cohorts of students -- usually through use of lectures and demonstrations. Class progress is in unison and there is little effort devoted to the accommodation of individual differences. Second, the network-based learning system may be implemented by the team teaching method. The students progress in groups but several instructors share the responsibility of presenting the planned curriculum. The major attraction of this approach lies in the fact that the teachers plan the total program and in presenting it attend to the interrelationships of the objectives in different subjects. Third, is the departmental approach wherein students receive instruction from a number of teachers in a number of departments. Fourth, teachers may offer instructional services from service centers. Finally, instructional services may be offered at a distance to students engaged in independent study.

This chapter addresses ways in which each of these implementation methods may be used in conjunction with a network-based learning system. Some of the common prerequisites of all methods will be examined first.

Preliminary Planning

Chapter 7 details the procedures by which the curriculum content and processes may be selected and organized, interfaces established, and networks integrated with other courses or programs. With a structured and modularized curriculum available before embarking on any particular method of implementation, the instructor has a clear view which reflects curricular objectives for a course, or sequence of courses.

The next step toward any method of implementation is to develop a Lesson Outline (i.e., a lesson plan of the type shown in Figure 22) for each instructional objective. First, record the objective to be met in each lesson. Though this may have been accomplished, in part or in total, during Step 7c of network construction (Chapter 7), it should be recorded as shown in Figure 22 together with other data such as the activity or objective number and the estimated or actual activity or lesson duration. Second, carefully delineate the content to be covered and the processes to be developed in order to meet the stated objectives. Content selection for specific lessons may vary from instructor to instructor and for that reason, it is not always specified as a part of the curriculum network development process. The scope (content and processes), and other data such as audiovisual aids, reference materials, interface data, and remarks are also documented on the Lesson Outline. When completed, this form serves as the instructor's worksheet, or lesson plan. These completed Lesson Outlines may be filed in loose leaf binders in numerical sequence for each course. Access to the filed forms is gained through the lesson numbers displayed on the master curriculum network, a document that should always be near at hand, or from the student record-keeping forms (Figure 23).

The next step involves translation of the Lesson Outline into a self-teaching lesson for student use and these lessons must be carefully constructed, because, in implementation they become an instructor surrogate. In some instances they may resemble home-study lessons. In other cases they may consist of audio or video recordings. Each lesson should provide a brief introduction of the concept or content of the lesson, a study outline, relevant information (or indications of suitable reference materials) and exercises to be completed. Each lesson may also include its own evaluation criteria and evaluation exercises.

Resource Management

The network-based learning system contains within it the key to instructional equipment and learning resource acquisition and management.

Efficient management of learning resources reduces the workload of teachers.

To employ this function effectively, learning resources in each instructional area (e.g., classroom, school) should be filed in pigeon-hole fashion in numerical sequence, the numbers assigned to each file or storage slot corresponding to the assigned lesson number shown on the Master Network and on the detailed Unit Networks. These systematically filed learning resources -- lessons, audio tapes, video tapes, films, filmstrips, overhead transparencies, computer programs and software, equipment kits, and lab kits -- are accessed by first determining the lesson number for which materials are required and then proceeding to the appropriate file to retrieve the materials.

In cases where a network-based learning system is developed and implemented manually, the Master Network may be used as the master key with resources types carefully coded into the network. Figure 26 shows an example.

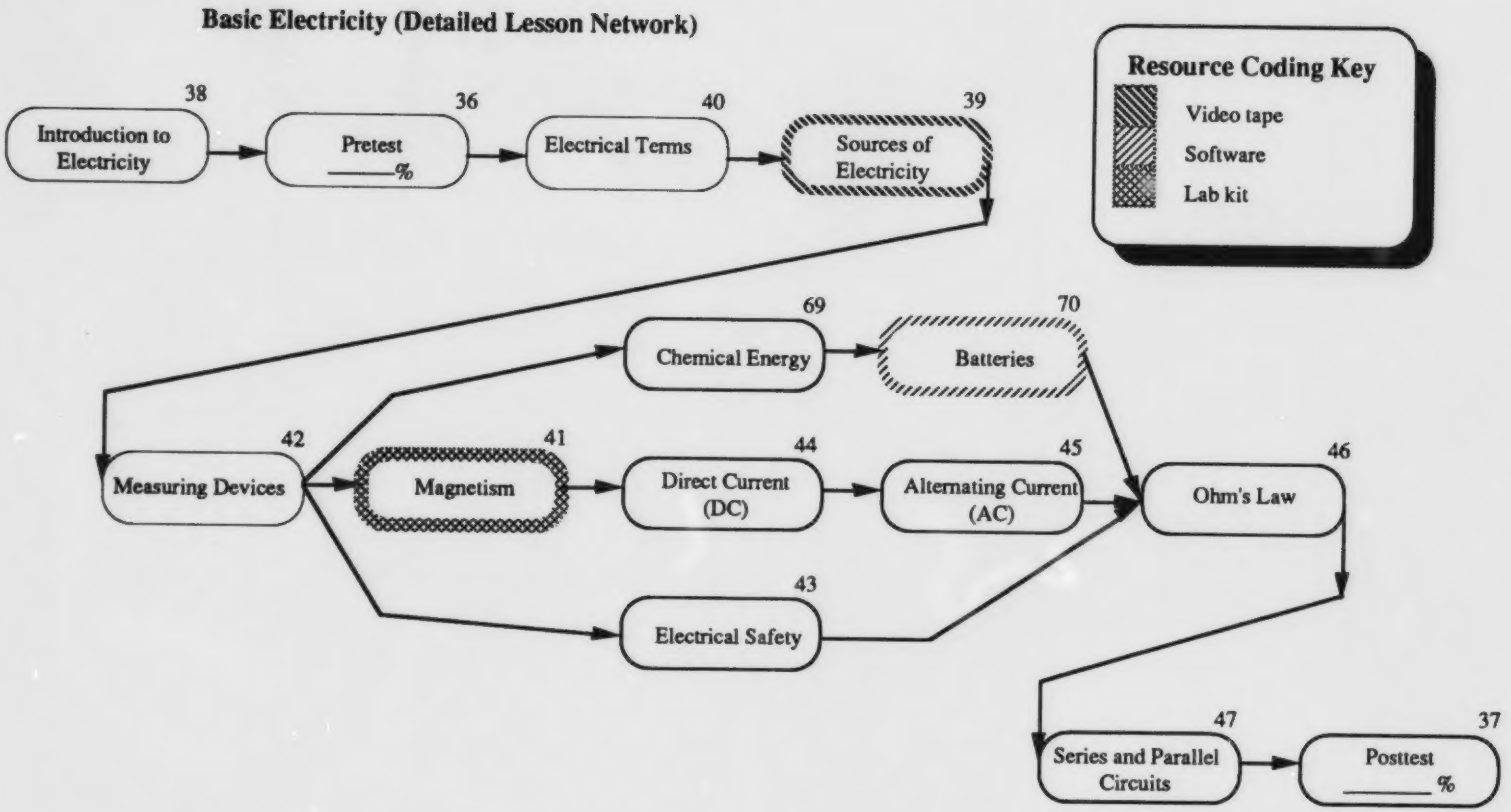

Basic Electricity (Detailed Lesson Network)
Resource Coding Key
Video tape
Software
Lab kit
38
Introduction to Electricity
36
Pretest ______%
40
Electrical Terms
39
Sources of Electricity
42
Measuring Devices
69
Chemical Energy
70
Batteries
41
Magnetism
44
Direct Current (DC)
45
Alternating Current (AC)
43
Electrical Safety
46
Ohm's Law
47
Series and Parallel Circuits
37
Posttest ______%

Figure 26. Method for coding the availability of learning resources on networks.

Computers may be programmed to predict where students will be and to queue up the needed learning resources.

In a computer managed system, the classification of resources, while following the same general pattern as in a manual system, may be more sophisticated. Resources associated with each lesson objective should be coded and filed in accordance with a more detailed description (e.g., English/Second Language, Imperial/metric, materials pertaining to particular ethnic groups or value systems, normal/low reading abilities, normal/low vision materials, and so forth). As the file of learning resources becomes larger and more complex, a computer must be relied on to flag quickly those items to be retrieved on an individualized basis and from a variety of storage bases including, hard copy, microfiche, software files, audio or video resources, laser discs, or compact disks. In the most sophisticated systems, the computer files may also contain the progress charts for all students, and on the basis of past progress the computer may be programmed to determine the materials most probably needed for use in the immediate future and to requisition automatically these materials from a centralized site. In effect, the computer is called upon to exercise complete resource management and inventory control. To do this, the computer must have access to centrally stored materials and there must be suitable communications linkages between these centralized centers and the locations at which the students will use the materials.

Organizing for Instruction

The network-based curriculum fits any teaching/learning situation.

One of the most significant factors influencing course or program implementation is adoption of a particular organizational style or styles. The matrix in Figure 27 suggests some of the more frequently used styles. While the teachers' involvements vary considerably, the various roles are quite clear. A brief description of each of the organizational approaches and the student grouping patterns is presented below.

Organizational Approaches

Traditional cohort processing approach. In the traditional approach, each teacher is responsible for the entire program for their students (a cohort). The teacher, using the network as a guide to sequence and direction, provides the instruction specified on the Lesson Outlines which, in this case, also serve as the lesson plans. When the class meets a specified objective it moves, under the guidance of the teacher, to the next unconstrained activity with the network serving as a reminder of the material covered and material to be covered as well as providing an overall indication of progress. By recording the actual time to complete each activity adjacent to the estimated completion time (t_e), the instructor can gauge actual progress against planned progress.

Team teaching approach. The team teaching approach is implemented in essentially the same way as the traditional approach with the exception that several teachers are involved; each concerned with a different segment of a mutually-developed and integrated network. Periodic team progress reviews alert everyone to potential delays in meeting interfaces or milestones and allows for alternative strategies to be developed.

		Student Grouping Patterns						
		Lock-Step		Non-Graded		Individualized		
		Heterogenous Groups	Homogenous Groups	Heterogenous Groups	Homogenous Groups	Individual Instruction	Individually Prescribed Instruction	Individually Proctored Instruction
Teacher Involvements	Traditional One teacher to one class with a fixed pupil/teacher ratio and all subjects							
	Team Teaching Several teachers plan and share in teaching a group of students							
	Departmentalized Several teachers independently teach a group of students							
	Service Centers Teachers provide service from kiosks or service centers							
	Independent Study Teachers provide tutorials for independent students							

Figure 27. Instructional approaches and student grouping patterns.

Continued evaluation of individuals rather than teams led to the demise of team teaching.

The team teaching approach attempts to provide the best possible education for children -- each teacher doing those things in which they excel. While team teaching initially failed to gain popularity (primarily because teachers were evaluated as individuals instead of as a team with the consequence that individualism flourished and teaming declined) it is still a viable approach and the network-based learning system does much to minimize individualism and to foster teaming and joint planning.

Departmental approach. The departmental approach entails students moving from specialist teacher to specialist teacher to obtain their instruction. In most cases there is only a minimum amount of joint or departmental planning. The students are expected to integrate the fragmented instruction they receive from different teachers into some sort of meaningful whole.

Service centers. Teachers may also offer services from service centers (something like kiosks in malls or other places). In effect the teachers would be more like consultants, tutors, or learning facilitators and the students would rely more heavily on mediated instruction.

Independent study. With suitable learning resources and a student record-keeping system readily available, instructional services could be easily extended to students seeking to study independently and away from schools. To support these students, teachers may provide tutorial services via telephones, facsimiles, or through the regular mail (as occurs in correspondence instruction today).

Student Grouping

Students may be treated as:

- *graded cohorts*
- *non-graded cohorts*
- *individuals.*

Student grouping may take any of at least three forms: lock-step or graded cohort processing, non-graded which amounts to mixed age/ability cohorts, and individualized instruction wherein each student is treated uniquely. The student groups may be either heterogeneous or homogeneous. Heterogeneous groups contain members exhibiting a wide range of differences, for example, age, grade level, interests, abilities, experiences. Homogeneous groups exhibit a narrower range of differences when assessed along these same dimensions.

The individualized and independent instruction approach to curriculum implementation is extremely useful because it accommodates many of the needs of individual students and for that reason it will be developed in considerably more detail than other approaches. A first consideration to be addressed in developing this approach is to survey the basic forms an individualized instruction program may take in order to determine the nature of the approach most likely to achieve success.

Individualized instruction includes both diagnosis and prescription.

Individualized instruction describes any of a variety of instructional methods that permit students to progress at their own rate. ***Individually prescribed instruction*** is a form of individual instruction which has been modified to the extent necessary to allow diagnosis of a student's needs and prescription of an individualized learning program. ***Individually proctored instruction*** is a form of individualized instruction consisting of: (a) a go-at-your-own-pace feature which permits each student to progress at a speed commensurate with his/her ability and other demands upon time; (b) a unit-perfection requirement for advancement which lets the student proceed to new material only after demonstrating mastery of that which preceded; (c) the use of lectures and demonstrations as vehicles of motivation rather than as sources of critical information; (d) the related stress upon the written word or other media form in teacher-student communication; and (e) the use of proctors which permits repeated testing, immediate scoring, almost unavoidable tutoring, and a marked enhancement of the personal-social aspect of the educational process. While these approaches may be developed and managed manually, computers may also be used in the delivery of programs. Two approaches to the use of computers are common: ***computer assisted instruction*** (CAI) and ***computer managed learning*** (CML). CAI resembles programmed learning and requires a good deal of student time at computer terminals. CML is a management program that directs and prompts students, yet demands little direct student use of computer terminals. The network-based learning system described herein most resembles a CML system.

Selection of an organizational style or styles to be used in implementation of a course or program, and the activities associated with it, constitutes the minimum level of detail required in a course or program action plan.

Instructional Techniques

A variety of instructional techniques are needed to accommodate individual student learning styles.

Figure 28 identifies some of the more common instructional techniques and grouping strategies. The matrix cells indicate all possible combinations while the check marks indicate the most appropriate combinations. While the grouping strategies are self-explanatory, the instructional techniques may not be and for that reason a brief description of each of the latter is provided. Some require substantial amounts of hardware. Some don't.

Instructional Techniques Requiring No Hardware

The ***case study*** uses descriptions of situations drawn from real life as a stimulus for group discussion and analysis. Cases may be presented in textual form or as video recordings.

The ***conference method*** is a group process that is useful in directed discussion, problem-solving, and analysis.

The ***demonstration*** is a method of providing skill training by showing students the performance that is expected.

The ***directed discovery method***, as the name implies, involves leading students through a set of specific experiences which culminate in the intended goal experience. The method systematically leads students to discovery of known information.

Experimentation is a method used to clarify and emphasize certain related pieces of information. Experimentation should be used more to verify than to discover information.

Grouping Combinations	Instructional Techniques and Strateegies	Hardware-Free Instruction																Hardware-Based Instruction		
		Case Study	Conference Method	Demonstration	Directed Discovery	Experimentation	Games	Group Dynamics	Induction Training	Job Instruction Training	Lecture	Orientation Training	Role Playing	Scenarios	Self-Directed Study	Simulations	Socratic Method	Computer-Assisted Instruction	Pictorially-Programmed Instruction	Programmed Instruction
Large Group	Teacher to Group	✓	✓	✓	✓				✓		✓	✓	✓	✓						
	Student to Group	✓	✓	✓		✓			✓				✓	✓						
	Media to Group	✓			✓		✓		✓			✓		✓		✓		✓	✓	✓
	Resource Person to Group	✓	✓	✓	✓						✓		✓	✓						
Small Group	Teacher to Group	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓			
	Student to Group	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓		✓				
	Media to Group	✓			✓		✓		✓			✓		✓		✓		✓	✓	✓
	Resource Person to Group	✓	✓	✓	✓						✓		✓	✓						
Individual	Teacher to Individual			✓	✓				✓	✓		✓			✓	✓				
	Student to Individual			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
	Media to Individual	✓			✓		✓		✓			✓		✓	✓	✓		✓	✓	✓
	Resource Person to Individual			✓	✓	✓														

Figure 28. Matrix of instructional techniques and student grouping combinations.

Games are simulations of practical problems which are usually simplified and compressed in time so that the essential principles and variables can be discovered quickly. Once discovered, the participant must analyze, evaluate, act, and react. Operations research includes methodologies for development of games.

Group dynamics are small group processes that allow participants to clarify their roles and to increase their understanding of others' roles through discussion and interaction.

Induction training is a useful method for installing a newcomer into an on-going process or activity. It reveals to the new participant the skills, attitudes, and so forth that are necessary for successful completion of his/her role. Induction training will be essential in the process of phasing teachers and students into a fully-fledged and on-going network-based learning system.

Job instruction training is a method of providing individuals or small groups with a set of skills and knowledge which is, in turn, applied under the guidance and direction of the instructor.

The ***lecture*** is a method of presenting theoretical or motivational information. It may also be successfully used to present skills when carried out in conjunction with a demonstration.

Orientation training may be defined as the planned and guided adjustment of students to the school, department, or course. It should provide answers to the students' questions about the organization's customs, rules, and methods of handling problems.

Role playing involves enactment of different roles as a means of analysis and evaluation of the rights and duties of a "specific role" in relation to a particular social setting.

Scenarios are selected portrayals of society under the influence of a specific set of converging variables. They are used for the purpose of discussion and analysis.

Self-directed study is any form of learning which occurs on the basis of a student's own direction.

Simulations enable students to face simulated real-life situations, to make decisions and to act and react on the basis of these decisions in a controlled, time-compressed environment. The activity leads, through analysis and evaluation, to improved decision-making skills. Many of the rules for developing simulations are contained in Operations Research literature.

The ***Socratic method*** is a questioning form useful in individual or small group settings. The student is led to a right conclusion through a series of questions that progressively reduce the margin of error in responses.

Instruction Techniques Requiring Hardware

Computer assisted instruction (CAI) is a type of instruction in which a computer is programmed to make the necessary responses as students interact with a sequence of learning steps. Typically, CAI is used in problem solving, dialogues, drill and practice, games, tutorials, simulations, and in discovery learning. CAI may also include a testing component. Due to the high cost of equipment and programs, CAI is most practical when costs can be prorated over a large number of students.

Pictorially programmed instruction (PPI) is a method for teaching processes to students with low reading abilities. Step-by-step sequences are taught by means of carefully sequenced sets of pictures and appropriate audio prompts.

Programmed instruction, which may be either linear or branched, consists of sequenced pieces of instruction which lead to a specific goal. Programmed instruction guides those students making correct responses and corrects those students that err. The program may be contained in books, filmstrips, tape cassettes, videos, or computers (CAI or CML).

Certainly, the matrix in Figure 28 does not contain all of the possible instructional techniques available to educators but it does offer some possibilities which may be put to use and which may in turn stimulate identification of other techniques.

An intervening medium comes between teachers and students in individualized programs.

Problems quickly arise as one moves to implement an individualized program and the reason is simple. If *x* number of students begin at some point in a program and at a specific time, at any later increment of time they will be found at *x* number of different positions along an achievement continuum. Obviously, the teacher can no longer be the chief source of information in the teaching-learning process: the students must, for the most part, interact with the teacher through an intervening medium.

A second problem may also arise. Some students will have broader experiences and will have mastered more material, and in different areas than others, at any point in time. Since it is foolhardy to expect students to follow identical programs, they must have access to flexible programs.

Clearly, any approach to individualized instruction must enable teachers and students to interact through some medium as the students follow flexible programs, yet the approach must remain administratively feasible.

The detailed networks of the sort shown in Figures 19, 20 and 23 are intended to serve several vital purposes.

The networks provide at several features of particular value to students. They serve as advance organizers of material to be presented and they serve as records of progress. Completion dates for each objective can be recorded thereby showing the progress of each student. Large, long-range goals are made to seem more easily attainable since they can be achieved in a series of short steps rather than in large steps taken over longer intervals. Networks contain the keys to the location of sequentially-stored print materials and other audiovisual aids. Each lesson identification number is used to identify all materials relating to that objective. Networks serve to allow students flexibility in selecting the units of study most closely related to other courses or interests they are pursuing.

The networks serve the teachers in three major ways: (a) they provide a convenient device on which to record student progress (pre-test scores, post-test scores and lesson completion dates); (b) they reflect the total program with all of the interrelationships among the objectives identified as an aid in the process of planning and developing lesson materials; and (c) they provide an easy method for adding, changing or deleting objectives. The impact of changes are immediately reflected throughout the total program because all of the interrelationships can be shown graphically.

The Unit Networks, together with the Course Networks, are of use to the administrative staff in a school because they are able to reflect to them the progress made by each student, they reveal program development progress, and they can facilitate judging of the general merit of the program without making it necessary to relate one lesson plan to another lesson plan, as is the case in the more traditional approaches. The latter point assumes, of course, that meaningful lesson plans are generally prepared by teachers in other programs and these are readily available for review.

Individualization substantially reduces equipment costs.

The networks also facilitate planning for resource expenditures since each activity line represents resource consumption. Networks, by enabling an individualized approach to instruction, reduce the amount of equipment required to accomplish stated goals. Where traditional approaches require enough equipment for class cohorts to undertake activities simultaneously, the individualized approach requires fewer sets of equipment, since students require it at different times during the course or program.

Counselling and Career Guidance

Networks serve as route maps for students planning careers or setting long-range goals.

In a fully developed network-based learning system, one may expect to find a wide array of objectives and learning outcomes, each described in several levels of detail (e.g., programs, courses, units, and lessons), and linked together into networks. As such, the learning system is remarkably useful in assisting or supporting the career guidance and counselling function.

On a daily basis students interact with the curriculum at the unit and lesson level. At this level students are able to see enough detail so that they can anticipate the next steps -- the network-based curriculum contains built-in clues and advance organizers.

When it comes to the longer range planning, the students may benefit from the perspective offered to them through viewing a Summary Network of units within courses, courses within programs, or programs arrayed side by side.

More importantly, by seeing where they are located in a program or course, students can also access information which will tell them the paths to follow to get to where they want to be (or need to be) in order to meet adequately the prerequisites for next stages in their lives. And even more importantly, the network-based learning system yields an indication of the expected time to get from one point to another point (i.e., the length of time to cover the span between two points in a network is the sum of the average completion times of all lessons on the paths that must be followed).

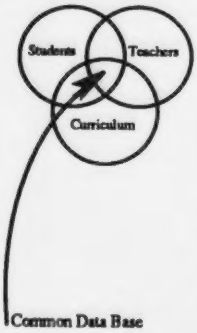
Summary

This chapter has described how a network-based learning system may be used to accommodate a number of organizational styles and grouping strategies and identified a number of instructional methods that can be used with the network-based learning system. The next chapter is devoted to a discussion of the evaluation systems imbedded in, or compatible with, the network-based learning system.

Chapter 9

Evaluation in the Network-Based Learning System

The network-based learning system integrates evaluation -- students, teachers, and the curriculum.



The network-based learning system supports three types of evaluation -- evaluation of students, evaluation of the curriculum, and evaluation of teachers. All of these evaluation mechanisms are based on students' performance within the network-based learning system.

In a sense, evaluation in the network-based learning system is based on a process or flow model: evaluation in the learning system may be regarded as evaluation of the channels or paths through which the students must flow. Following the analogy a little further, it is reasonable to think of student progress as units flowing through these curriculum channels. At the same time, one might regard teachers as the managers and facilitators of learning, and together with the curriculum, they have an impact on student achievement. This flow pattern can be shown graphically (Figure 29).

Having established that the network-based learning system may be regarded primarily as a device for processing students, then carefully selected flow-processing tools may be used in development of a strategy for evaluation in the network-based learning system.

For each course, unit or lesson there are two basic types of evaluation that should occur: evaluation of the students' performance and evaluation of the curriculum. Specifications established in Chapter 7 declare that objective statements for each course, unit or lesson should include: (a) indications of the student performance that should be evaluated, and (b) indications of the curriculum objectives that should be evaluated.

The flow of students through the curriculum provides the basic data for evaluation. These data include: (a) the numbers of students that flow past each node or junction in the curriculum network, (b) the rate at which students move past each node or junction, and (c) the gains in student achievement made between selected milestones (something equivalent to the value-added concept in economics).

There are a number of methodologies available to accomplish the necessary evaluations. As was the case with the instructional strategies

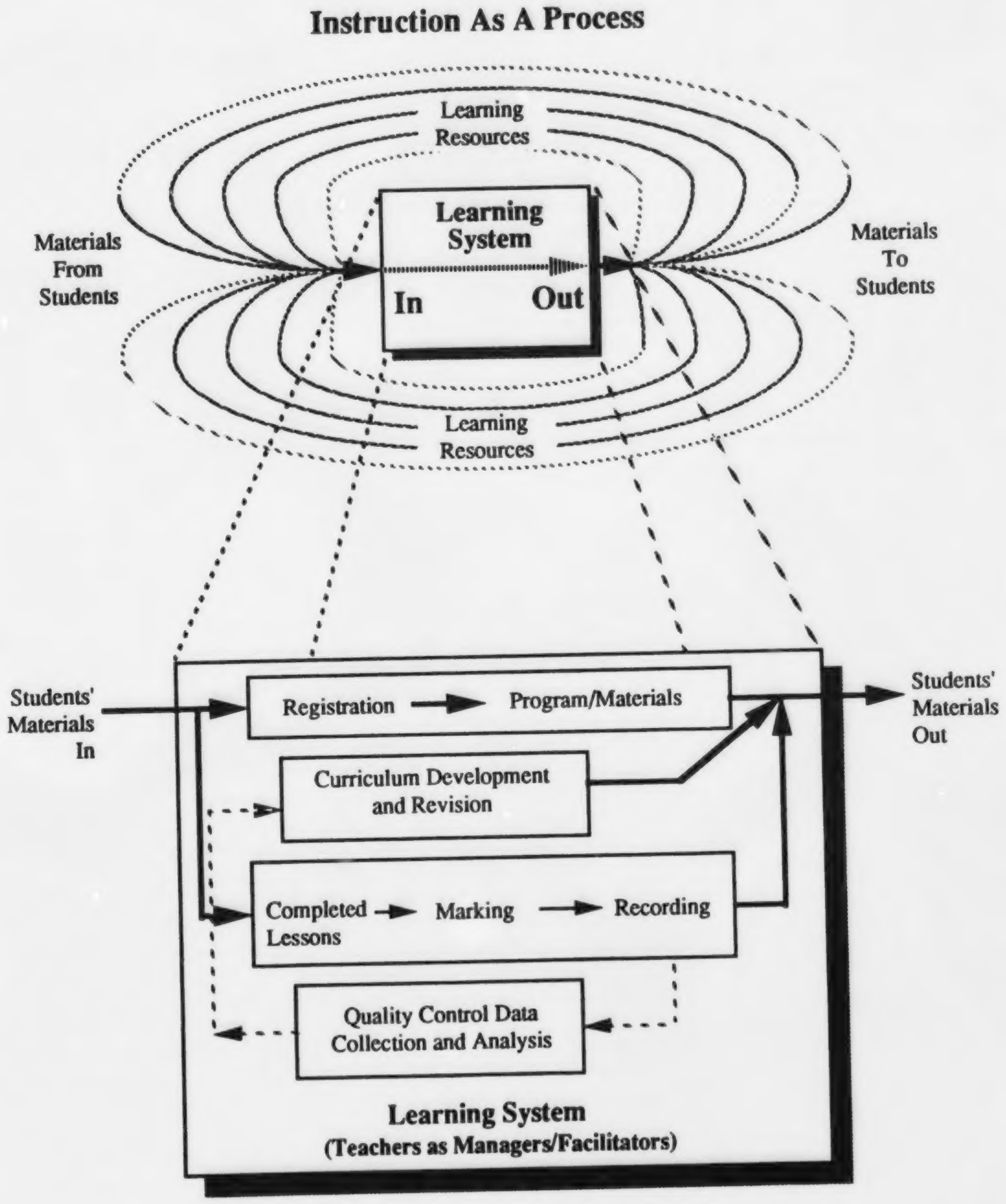

Instruction As A Process
Learning Resources
Learning System
Materials From Students
Materials To Students
In
Out
Learning Resources
Students' Materials In
Registration
Program/Materials
Students' Materials Out
Curriculum Development and Revision
Completed Lessons
Marking
Recording
Quality Control Data Collection and Analysis
Learning System
(Teachers as Managers/Facilitators)

Figure 29. A model depicting instruction as a flow process. Monitoring and evaluation may occur at a number of points along the flow path.

discussed in Chapter 8, only a few of the evaluation methodologies are discussed here and those only to serve as illustrations of the potential scope of evaluation in the network-based learning system.

Evaluation of Students

Students are evaluated on work completed -- not on time spent in the course.

There are three important sources of information on which to based evaluation of students in the network-based learning system.

The first type of evaluative information is that which is imbedded in each lesson. Lesson objectives should be stated in terms which include student responses and intended learned behavior or learning outcomes. This type of objective includes statements about performance including descriptions of: (a) the behavior or performance to be demonstrated, (b) the degree to which the performance should be demonstrated, and (c) the conditions under which the performance should be demonstrated. A number of evaluation tools suitable for assessing specific student performance are discussed later.

The second type of evaluative data that is collected in the network-based learning system is the pre-test and post-test scores for each student at the course and unit levels. These data clearly indicate the levels of achievement being obtained by each student. Pre-tests and post-tests may be created manually for small projects, but, for the larger projects a computer should be used to manage a bank of test items. As students arrive at designated milestones, a computer may be programmed to deliver and score suitable tests.

The third type of evaluative data about students is the amount of work they have actually accomplished. This is computed by adding up all of the activity times (t_es) for the objectives completed. The activity times (t_es) are calculated by measuring the time that it takes average students to complete each activity. In a manually-operated system these data are collected on a tally sheet and analyzed periodically. A computer-based system may rely on the computer to collect and process this information as a routine.

In summary, the basic evaluation of students involves use of three pieces of information: (a) the changed behaviors measured by each lesson, (b) the total amount of work accomplished in a period, and (c) the amount of achievement or learning that occurred between pre-tests and post-tests.

Other student evaluation methods and instrumentation should be planned during the program planning phase.

Individual progress charts include any of a number of devices for collecting and assessing student evaluation data. The critical incident process is a check-off evaluation (as shown in Figure 30 and 31) which is suitable for periodic evaluations of individuals. The first of the two evaluation sheets contains several subdivisions within each of the following general areas: results, methods, personal qualities, and general knowledge. For ease of evaluation, each subdivision is judged and ranked into one of six performance levels: exceptional, exceeds requirements, meets requirements well, meets requirements adequately, somewhat below requirements, and unsatisfactory. Figure 31 contains a

Name:

Date:

Circumstances surrounding evaluation/appraisal:

				Rating Scale						
				1	2	3	4	5	6	
		Key Words	**Performance Areas**	Unsatisfactory	Somewhat Below Requirements	Adequately Meets Requirements	Meets Requirements Very Well	Consistently Exceeds Requirements	Exceptional	**Score**
Results		Volume	Number of tasks accomplished			▨	▨			
		Quality	Excellence of work completed			▨	▨			
		Economy	Efficiency with which the work was completed			▨	▨			
Methods	**(Problem-solving)**	Developing	Search for, collection and preparation of information to solve problem			▨	▨			
		Investigating	Recognition of needs and development of improvements to solve problem			▨	▨			
		Organizing	Arrangement of tasks for most effective handling			▨	▨			
		Communicating	Proper use and interpretation of information			▨	▨			
		Controlling	Evaluation and follow-through to assure conformance to plan or procedure			▨	▨			
	(Contact activities)	Coordinating	Development of harmonious working relationships			▨	▨			
		Negotiating	Making arrangements with people with vested interests in activity or task			▨	▨			
		Representing	Represents organization, agency or program with others			▨	▨			
Personal Qualities		Stability-maturity	Personal adjustment as in self-control, self-confidence, self-reliance			▨	▨			
		Cooperation	Tact, courtesy, and diplomacy in getting along with others			▨	▨			
		Persuasiveness	Capacity to influence and secure willing cooperation from others			▨	▨			
		Management attitude	Loyalty and fair play towards organization and peers			▨	▨			
		Motivation (Drive)	Ambition, physical energy, enthusiasm and interest in getting task performed			▨	▨			
Know-how		Knowledge	Amount of information possessed through education, experience, or research			▨	▨			
		Skill	Application and use of knowledge and abilities in a practical situation			▨	▨			
		Attitude and interests	Personal feelings towards institution, the task, and others			▨	▨			
		Ability	Basic mental and physical capacity			▨	▨			
									Total Score	

Comments (comment on all ratings which fall outside the shaded area.

Figure 30. A Critical Incident appraisal for evaluating general performance.

	Unsatisfactory	Somewhat Below Requirements	Adequately Meets Requirements	Meets Requirements Well	Exceeds Requirements	Exceptional	
Content	1	2	3	4	5	6	**Score**
Definition of problem							
Establishment of problem significance							
Scope of research							
Recency of research							
Analysis of research							
Synthesis							
Conclusions							
Identification of implications							

Form and Style							
Correct use of punctuation, spelling and grammar							
Format							
Organization of research report							
						Total Score	

Comment on all ratings outside the shaded area:

Figure 31. A Critical Incident evaluation format for assessing the quality of research papers.

simplified form suitable for evaluation of research reports or essays. As the name implies, the critical incident process may also be used on an *ad hoc* basis to describe any critical incident related to students' performance, when it occurs.

Matrices provide multi-dimensional record-keeping and evaluation systems. The convention is to list aspects to be evaluated on one axis with the levels of achievement identified along the second axis.

Tests encompass a wide array of evaluation devices. Figure 32 identifies some of the more common categories of tests. The network-based learning system accommodates data derived from any of the testing modes.

Evaluation of Teachers

Teachers demonstrate accountability by pointing to the sum of individual gains made by students.

While the network-based learning system was not designed primarily as a tool to aid teacher evaluation, it does provide the means for systematizing teacher evaluation and it makes it possible for teachers to demonstrate accountability both to the public and to teaching peers and administrators.

Reference to Figure 29 helps to understand the nature of teacher evaluation. In that illustration, students are seen to constitute a flow. Monitoring and assessment of students at the input to the system and at the output provides important information. Specifically, it provides information about the numbers of students, the gains made by students between the input and the output, and the length of time required by students to achieve these gains.

Evaluation of teachers in a network-based learning system could be achieved by comparing teachers on the basis of the following equation:

$$p = \frac{n^a \times g}{t}$$

where:

p = teacher productivity,

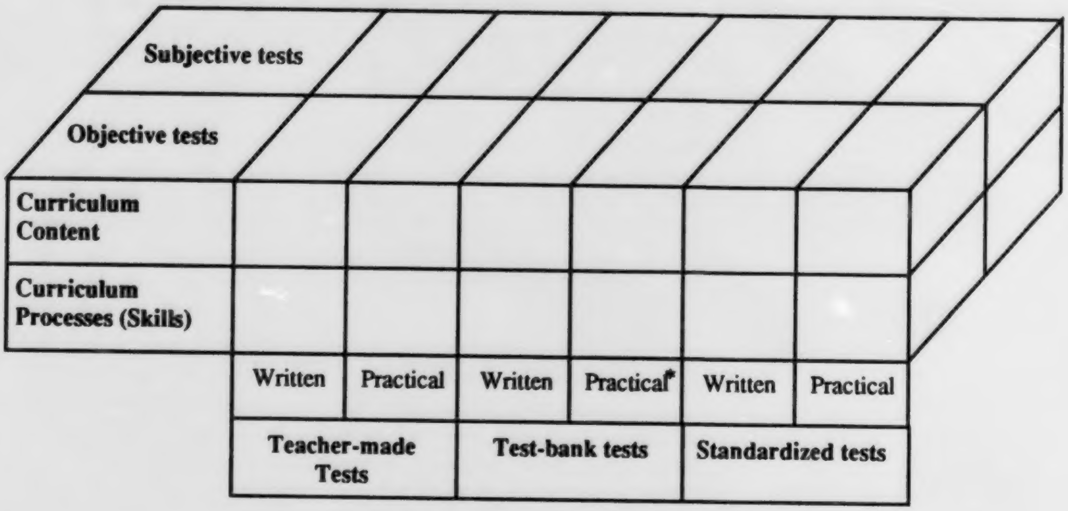
n = numbers of students,

a = a multiplier describing student ability and aptitude,

g = average achievement gains expressed in completed hours of instruction, and

t = elapsed time.

Adoption of an evaluation equation of this sort would serve to free teachers to manage the learning environment and to engage in curriculum quality control -- activities which can be clearly linked to increased productivity.


Subjective tests
Objective tests
Curriculum Content
Curriculum Processes (Skills)
Written
Practical
Written
Practical*
Written
Practical
Teacher-made Tests
Test-bank tests
Standardized tests

*May be interactive with a computer

Figure 32. Test types capable of providing student evaluation information and input data for development of Individualized Educational Plans.

Evaluation of the Curriculum

As with the evaluation of students, the evaluation of the curriculum is most easily accomplished if specific curriculum objectives are available to guide the evaluation.

Curriculum quality is monitored through use of:

- *gains between pre-tests and post-tests*
- *lesson difficulty indicators*
- *lesson uncertainty indicators.*

Lesson level evaluation. Lessons within units are evaluated by means of a procedure first described in an article by the author in 1977 (Hathaway, 1977: 5-11). The first step in the evaluation procedure is collection of information pertaining to the length of time it takes students to complete each lesson or objective. This information may be obtained in a manually-operated system by using a tally sheet to record the elapsed time between lesson or objective completions or the same information can be obtained by means of a computer when one is used to manage the learning system. Periodically these data are analyzed to determine the average time for completing each objective (t_e) and the standard deviation (sd) of completion times for each objective.

The average completion time (t_e) represents the overall difficulty of the lesson or objective. The highest levels of student motivation seems to occur when all of the lessons are of uniform difficulty or when they fit the curve shown in Figure 33. By the same token, units and courses (and especially courses) should be approximately the same weight (i.e. they should require approximately the same length of time for completion).

The standard deviation of the lesson or objective completion times (sd) (discussed in Chapter 7) may be regarded as an expression of the degree of uncertainty within each lesson. The standard deviation tends to increase when elements of the lesson are either very difficult or very easy for some students to complete. An objective or lesson uncertainty factor (q) may be derived by dividing the standard deviation by the average completion time -- in effect determining the standard deviation attributable to a unit of time by means of the following formula:

$$q = \frac{sd}{t_e}$$

Objectives or lessons within a unit may be rank-ordered in terms of the uncertainty factor (q) with the highest indices representing those lessons or objectives most in need of analysis and revision. Trouble-shooting a lesson or objective to find its weakness is not always easy. Figure 24, and the discussion devoted to it in Chapter 7, clearly depicts this subtlety.

Unit level evaluation. Unit evaluation occurs as a result of pre-test and post-test achievement results of students. Units within a course are ranked on the basis of their teaching indices (average post-test score minus average pre-test scores). Again, the weakest units should be the ones selected for further analysis and possible revision.

Course level evaluation. Course evaluation is accomplished by using scores from pre-tests and post-tests. For individual students, these tests assess the actual achievement attained in the course. When test results are aggregated together and analyzed, they yield data which helps evaluate the course. For example, the average pre-test score

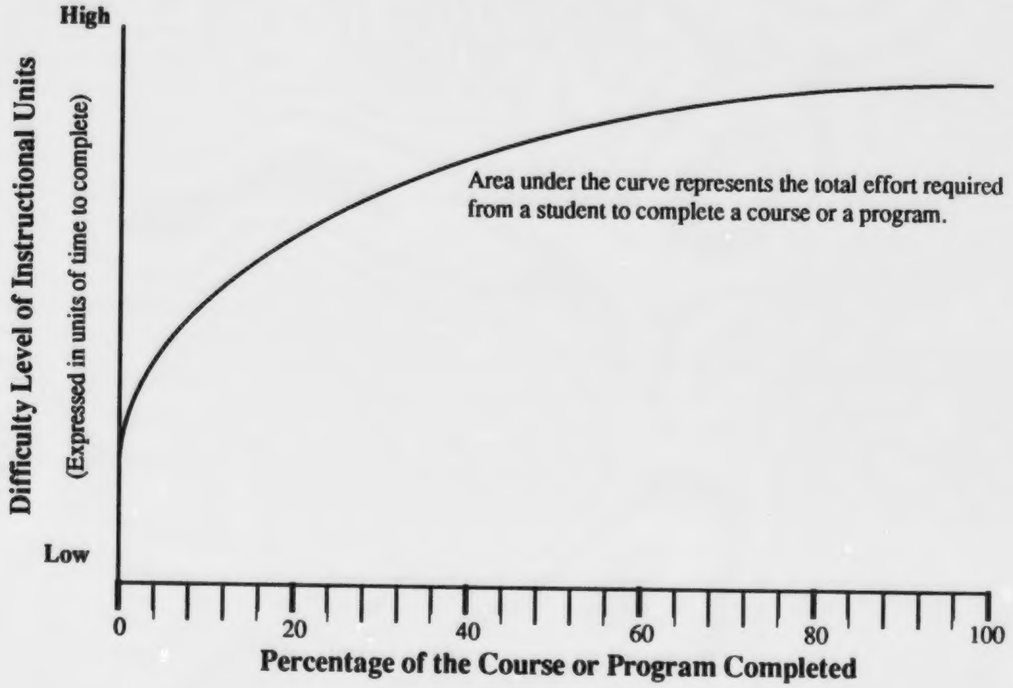


Figure 33. Recommended relationship between instructional difficulty and percentage of the course/program completed.

subtracted from the average post-test score provides a measure of the actual learning occurring in the course. When a set of courses within a program are analyzed in this way, it is a simple matter to rank-order the courses in terms of their ability to teach. Those courses bearing the lowest teaching indices should be the courses selected for further analysis and possible revision.

Program level evaluation. Program evaluation may be based on student achievement tests results administered when students exit the program. For the student, these tests carry with them some aspect of certification or acknowledgement of demonstrated achievement. To the program planner, the combined scores of all exiting students represents an overall report card on the program. Only in those cases where the program exhibits some problems or causes for concern will further program analysis and appraisal be required.

Identifying and Correcting Weaknesses in the Network-Based Curriculum

Defects in the curriculum may be corrected through use of a variety of tools and techniques.

There are a number of tools which are of great use to the curriculum planner when the time rolls around for evaluation and revision of the curriculum: human factors analysis, cost reduction and value analysis, reliability analysis, operations research, and suggestions. Each of these tools may be brought to bear when problems are discovered through the evaluation methods just outlined. When units or lessons within units are found to have low achievement gains or give indications that students are having difficulty each of these tools should be considered in turn for its potential in solving the problem.

Human factors analysis provides a framework for examining the lesson or unit in order to determine if there are ways that the student is being overtaxed in some way. Table 1 (presented in Chapter 5) identifies a number of elements of the teaching-learning situation that might be meaningfully examined for their impacts on student performance. Appendix I contains other suggestions.

Cost reduction involves examination of alternate and cheaper ways of achieving the required or stated objectives. Actual budgetary data is required before this type of evaluation can be fully applied. ***Value analysis*** enters into the picture when problems of high resource consumption occur. Attempts should be made to try and identify alternatives that meet the requirements but do so at a lower cost or with improved quality.

Reliability studies serve to assess the degree to which the levels of attainment achieved on repeated applications of objectives fall with planned limits. To the extent that the levels of attainment fall outside the predetermined limits, reliability-related tools and methodologies are available for use.

Diluting courses is an unacceptable strategy for correcting problems of unreliability.

When lessons or sequences of lessons are found which give the students a great deal of difficulty -- few students master the lesson or lessons -- then it is appropriate to analyze the reliability of particular lessons or all of the lessons in the unit. It should be recalled from earlier discussion in Chapter 5 that the overall reliability of a sequence of activities is the product of the reliabilities of each activity in the sequence. It should also be recalled that the reliability can be improved by paralleling the problematic unit or lesson with alternate paths (also refer to Figure 21). In a practical sense this means that if students are experiencing difficulty with one mode of instruction in a particular part of the curriculum, it might be appropriate to provide an alternative instructional strategy. For example, if the principle medium of instruction for the lesson or lessons is print material, group activities or video-based materials might prove more effective. It can't be stated strongly enough that watering down a unit is not an acceptable way of improving reliability. Strategies must be found which achieve the same products or outcomes -- the same in terms of both quality and quantity. Nevertheless, time for completing objectives may vary.

Operations research may be used to solve problems such as determining the number of items of equipment required to meet students' needs in different curriculum implementation modes.

Suggestions solicited from those participating in the educational program (students and teachers) may lead to new insights worthy of pursuit and alternatives that may be more productive.

As with instructional techniques, every planner will be able to add many other evaluation methods to the list. Some will be applicable to all levels (as most of these are) and some will apply best to selected levels.

Summary

Evaluation of students, teachers, and the curriculum has been discussed and methods presented which achieve these functions, all on the basis of the way students perform in the learning system. In addition, hints have been provided which suggest how the curriculum might be improved once it has been found to have weaknesses.

Chapter 10

Educational Facilities for the Future

Planning Educational Facilities

Traditionally, schools have been designed to support an assembly-line model of education -- classrooms are scaled to accommodate a group or class of students and one or more teachers and the students are processed in cohorts for a semester or for year-long periods. The network-based learning system is an application of technology that permits a departure from education as a cohort-processing function to education as an individualized experience -- an educational pilgrimage undertaken by each student. Because traditional educational facilities are designed to support the cohort processing model they may constrain the full exploitation of the network-based learning system. For this reason some consideration is given to design parameters for educational spaces capable of accommodating increased use of technology and of facilitating individualized instruction.

In company with technologically-induced changes to education and educational delivery are other broad factors which require the attention of facility planners if the designed facilities are to be resistant to premature obsolescence.

Public educational facilities should be planned to meet a broad array of social needs.

One of the factors that makes educational facility planning so difficult is the scope that the planning must encompass. Education is only one of a number of social programs that could benefit from broadened and integrated planning perspectives. Indeed, it may be naive to think about public facilities as being exclusively intended for a specific program (e.g., education). Perhaps public facilities should be designed to serve several programs or to meet several societal needs simultaneously. Figure 34 describes a planning process which could, if followed, increase the probability that public facilities are designed and developed with a capability for serving a broad array of needs beyond education.

The framework in Figure 34 suggests that educational facility planning should begin with an attempt to study the future and to develop one or more possible and plausible scenarios. A preferred scenario is then analyzed for potential social policies and plans. These policies may be narrow and focus only on education or they may be broad and span a number of social programs. The preferred mode would be to first consider education within the context of other social programs. When that approach is followed, it becomes much easier to plan facilities that readily serve multiple needs.

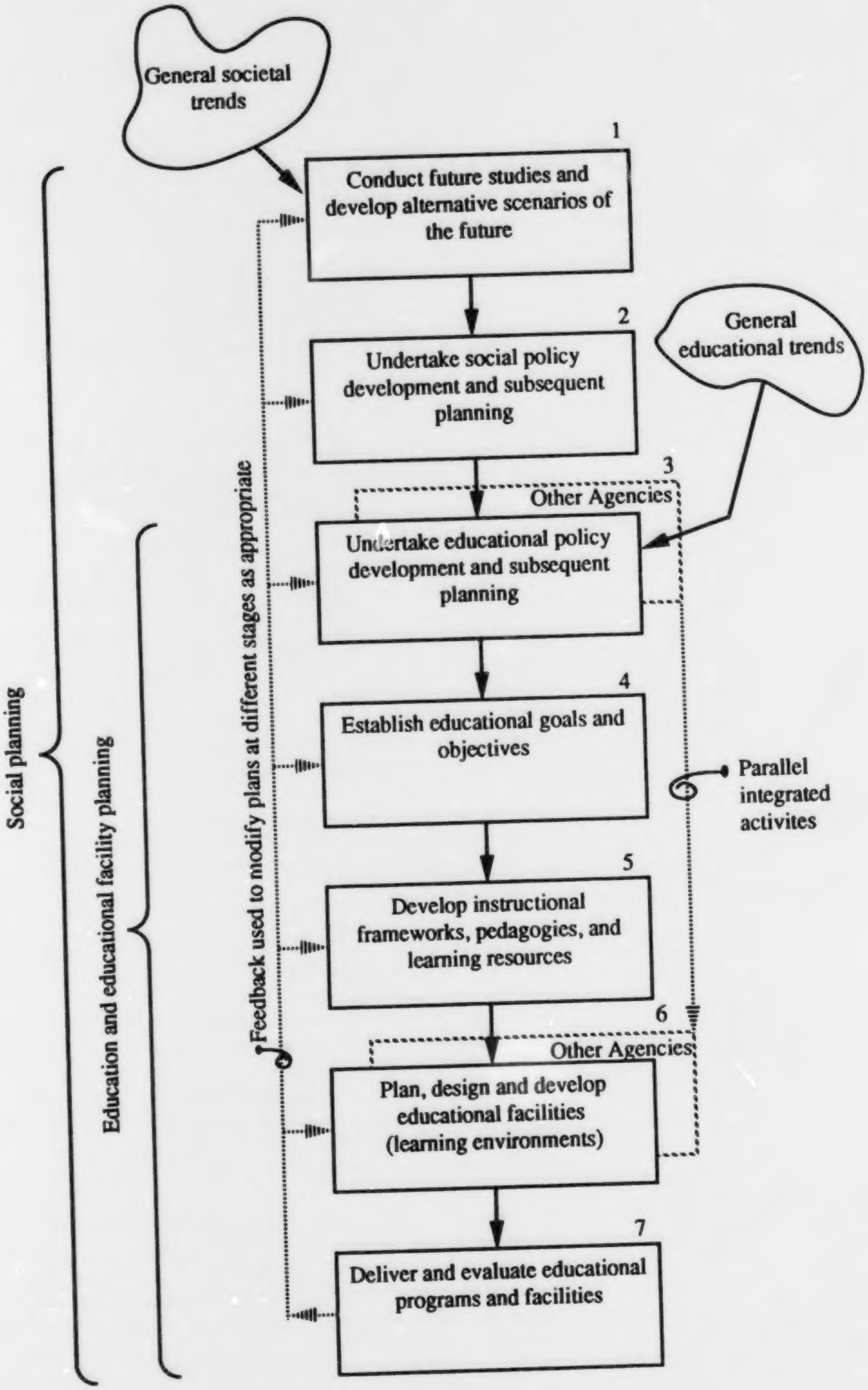

General societal trends
1
Conduct future studies and develop alternative scenarios of the future
2
Undertake social policy development and subsequent planning
General educational trends
3
Other Agencies
Undertake educational policy development and subsequent planning
4
Establish educational goals and objectives
Parallel integrated activites
5
Develop instructional frameworks, pedagogies, and learning resources
6
Other Agencies
Plan, design and develop educational facilities (learning environments)
7
Deliver and evaluate educational programs and facilities
Social planning
Education and educational facility planning
Feedback used to modify plans at different stages as appropriate

Figure 34. Stages in the macro social planning process.

As the focus of planning narrows to the educational domain a more specific set of guidelines or parameters are proposed to guide facility planners in development of the educational facility plans (Henchey, 1986d).

- Ensure that the facility plan balances rapid, continuous and erratic change with some elements of continuity, stability and calm.

- Regard learning as associated with all (or most) stages of life, with several institutions (e.g., schools, colleges, universities, and workplaces), and for a variety of purposes (e.g., vocational preparation, leisure and personal interest, custodial care).

- Recognize that advances in communication technology and brain research are broadening our conception of how learning takes place.

- View the educational system as including a formal dimension (elementary, secondary, post-secondary levels) and a non-formal dimension (libraries, video clubs, museums, business and industrial training programs, information networks, churches, volunteer organizations, community activities, the media).

- Educational facility planning should include a framework which ensures that decisions are made which satisfy the broadest possible array of societal needs. Decisions about educational facilities are usually of the following types: decisions to provide new facilities; decisions to provide alternative facilities to meet the various client needs; decisions to adapt educational facilities to other purposes; and decisions to retire existing facilities. These decisions may best serve public policy if they recognize the concurrent need for: (a) custodial institutions for child care and care of the aged, both combining supervision, services, and learning stimulation (it may be linkages between child-care and elderly care facilities can be strengthened, with staff moving back and forth between them); (b) resource institutions built around unusual, costly, or complex resources, on the model of a museum or library, linked with other resource centers through information networks, and providing points of access for the public -- such centers would combine special technological resources (e.g., computer-based learning systems, simulation activities), cultural resources (art), and person-based resources (artists, musicians, writers, scholars, artisans, master teachers); and (c) service institutions offering individual and group learning programs (structured in a variety of ways), as well as evaluation and certification services.

- Some of these facilities may be: linked to other people-serving institutions (day care, old-age care, health facilities); integrated into private organizations (service centers for managers within a business); incorporated within other designs (office towers, shopping malls, apartment complexes); or serving as extensions of media (communications networks and computer facilities). Some may have public funds and control, some may be private and not for profit, and some may be profit oriented (franchises).

Facilities should be designed to preserve scarce resources.

A notion of scarcity runs through most of the scenarios used to help us understand education in the future, and creative ways for providing efficient educational facilities will be required in the future. Resources such as fuel, water, pure air, green space and land may become significantly more scarce in the future and, as a consequence, these elements must be considered in the planning and design of new facilities. Moreover, the overall utilization ratio for educational facilities, which is about 14 percent today (i.e., 6 hours per day, 200 days per year), will have to be improved. Educational facilities (indeed all public facilities) should be used for the entire year and for much longer periods each day.

Unpleasant as the prospect may be, it may also be worthwhile to consider making some public facilities disaster resistant. The results of natural disasters, industrial accidents, social strife or terrorism in communities could place great demands on public facilities to serve as refuges and shelters and to provide emergency supplies and support systems. As the level of technology increases in schools, there will also be the added need for increased equipment security.

Facilities influence learning and human performance.

In addition to these broad factors, the National Interface Task Force (Hawkins & Overbaugh, 1988: 7) has examined the interface between the facilities and educational programs and identified several additional areas which should be considered when educational facilities are being planned.

- The facilities should be regarded as an integral part of the community -- they should reflect community values and goals and they should facilitate attainment of community and cultural needs. To meet this criterion, educational facilities should: be designed as the result of joint planning with the community; serve joint uses; be accessible during extended hours on a daily basis; serve as emergency shelters if required; and have the flexibility to adjust to changing needs. Moreover, all public buildings, and especially schools, should contain some features that express the surrounding cultural or community and link the past with the present and the future. Designing a replacement school to include a bell and bell tower salvaged from its predecessor is one simple example.

- The facilities should be adaptable to the users' needs. Spaces should have an element of flexibility (i.e., convertible, versatile and expandable/contractible) which can be enjoyed on an hour to hour, day to day, and week to week basis. The learning environments should be designed to enhance learning and human performance. A number of these important factors are discussed in more detail in Appendix 1.

Means should be included in the basic facility designs to accommodate emerging and innovative technology and pedagogy. There should be a preponderance of multi-function spaces and very few spaces that accommodate only single functions. Within schools (and within classrooms) interrelated functions should be accommodated in proximate shared space.

Teachers need private space -- private offices.

- Educational facilities should enhance the opportunities for teachers to function as professionals. Personal spaces and work areas should allow teachers to operate as true professionals. In addition, spaces should be provided to support the staff and volunteers that surround teachers. This is especially important in any facilities intended to support individualized instruction where the teacher is a facilitator of learning rather than a dispenser of knowledge.

- Facility designs should foster communications between and among students, teachers, administrators, parents and other community members.

- Educational facilities should be exemplary in creating settings conducive to learning and human performance. There are many facets on the interface between facilities and programs and many of these facets have a potential for aiding or inhibiting learning and human performance.

- All educational facilities, and especially those intended to serve individualized or customized learning systems must accommodate the individual learning styles of students. To do this facilities should: provide a variety of habitats (learning centers, lofts, project spaces, common gathering areas); accommodate a variety of learning resources; be scaled to a variety of users; and be accessible on a user demand basis.

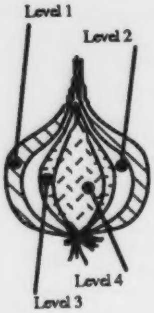
Impacts of Technology on Education

Technology (i.e., computers and communications media, management sciences, and quality control tools) carries with it an expectation that it will transform many aspects of education -- the content and body of knowledge taught, the way education is delivered, and the types of facilities required to support technologically-enhanced educational systems. While there are many model computer labs in schools across North America, there is still a nagging notion that technology has not been fully exploited and that notion fires a desire to continue the search for high-tech, obsolescence-immune educational facilities. Up to now most of the searches have ended in frustration -- technology still remains only an add-on in education.

Planning educational facilities that are immune to premature obsolescence is a complex task. Planning to preserve this immunity in the face of technological change is difficult because many key decisions are outside the domain of educational facility planning. Nevertheless, a view of the facility is useful as an aid in planning to avoid obsolescence.

Educational facilities are immunized against obsolescence by designing them as systems within systems.

The facility may be thought of as consisting of four subsystems: the shell or structure, the infrastructure, the interior environment, and the work spaces. Each of these subsystems has its own time horizon and its own rate of change and each level should be designed in such a way that changes and renovations in the levels below it can be carried out with the least possible impact. As illustrated below, changes to interior walls and partitions (Level 3) should not have a significant impact on the heating, lighting and ventilation system (Level 2).



Shell or structure subsystem (Level 1)
(foundation, exterior walls, roof)
Life span without substantial change: 50 - 100 years

Infrastructure subsystem (Level 2)
(heating, lighting, ventilation, primary power distribution, primary communications)
Life span without substantial change: 20 - 25 years

Interior environment subsystem (Level 3)
(ceilings, interior walls, partitions, secondary power distribution, secondary communications)
Life span without substantial change: 5-10 years

Work spaces subsystem (Level 4)
(furniture, moveable walls and screens, equipment)
Continuous change

While each of these four subsystems must be addressed in planning educational facilities, a number of other pivotal decisions must be made before the facility planning can begin.

Technology impacts on both the delivery of education and educational facilities.

Technology has major implications, not only for the delivery of education, but also for facility management, operation, and control. For example, technology and robotics might be used to enhance the operation and maintenance of educational facilities as well as altering the nature of some of the custodial services (e.g., robots may be used to clean floors). Important as these considerations are, it is not the intent of this chapter to focus on these obvious implications, but to focus on potential changes to educational delivery and its implications for facilities.

Facility designs are constrained by decisions regarding educational delivery modes.

When it comes to the delivery of education, important decisions must be made with regard to the way technology will be used in the delivery process -- in teaching and learning. Technology makes it possible to individualize and customize many of the processes. The pivotal question to be answered before plans for schools are developed are: What are the instructional frameworks, pedagogies, learning resources, and delivery systems that will be used in the schools (i.e., Stage 5, Figure 34)? Will technology be used to support traditional educational practices (i.e., the assembly-line, cohort processing of students) or will technology be used to customize and individualize education?

The basic building blocks of schools change in the face of individualized instruction.

Historically teachers have been regarded as the fountains of knowledge and students as cups waiting to be filled. Tradition coupled with the collective bargaining process has led to the present state of affairs wherein teachers are expected to serve classes of students and the class sizes hover in the range of 20 to 25 students. Following this logic, it is easy to understand why classrooms are regarded as the smallest building blocks in schools and the number of classrooms in a school is determined by the following general formula:

$$\textit{number of classrooms} = \frac{\textit{enrollment}}{\textit{pupils/teacher}}$$

As individualized or customized educational programs are designed, the concept of classroom becomes more or less irrelevant and the notion of individual workstations becomes important: a workstation being a place where a student can work to achieve a particular objective or a particular type of objective. While general purpose computer workstations are presently fairly well defined, it is important to think about other kinds of workstations -- science workstations, mathematics works stations, word processing workstations, and so forth. More will be said about some of these workstations later in this chapter. At this point it is important to consider individual workstations, rather than classrooms, as the smallest building blocks in schools. The number of workstations required in a school may be calculated by the following formula:

$$\textit{number of workstations (by type)} = \frac{a \times n}{\textit{time available per day}}$$

where:

a = amount of time per workstation (by type)

n = number of students desiring to use the work station per day.

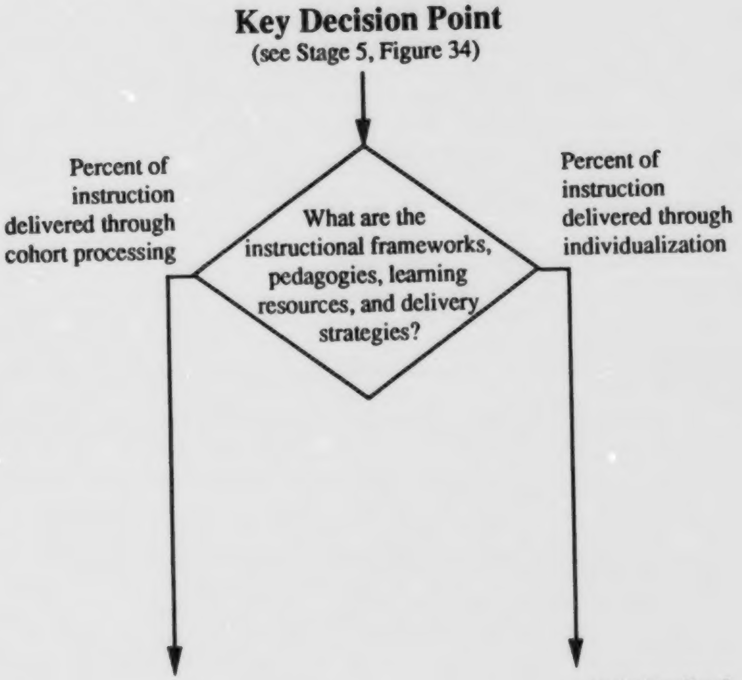
As illustrated by Figure 35, facilities required to support these two different forms of educational delivery (cohort processing and individualized study) are remarkably different. If the decision is to use technology to support cohort processing delivery systems, then such things as computer labs, multi-station labs for business education, and classrooms that handle class-size lots of hardware will be the norm. If the decision is to use technology to individualize and customize instruction, then classrooms and schools must be designed to be quite different from those found today -- one important difference being a need for fewer spaces designed for group activity and more spaces designed for individual and independent activity.

Learning Spaces for the Future

Appropriate uses of technology in education may lead to far greater individualization of instruction than is the case today in the cohort-processing form of educational delivery. Yet, until the educational delivery mode is specified by the educators, it is difficult to plan to accommodate emerging technologies. Once it is acknowledged that appropriate uses of technology ultimately lead to changes in the way people do their work, the basic definitions of teaching, schools and classrooms should change. Teachers could become facilitators of learning and students could engage in far more individualized and customized education. Even the time when educational services are offered could change. Schools may very well be open for business more hours per day, more days per week, and more weeks per year than is the present case.

Classrooms in the future may look like multiple activity labs.

To support individualized instruction and appropriate uses of technology, the classroom of the future should be regarded as a multi-activity lab and the best model might be the multi-activity industrial arts (IA) labs. In these labs, a number of different workstations may be arranged to provide for ease of supervision by a single instructor whose other major roles will be facilitation and evaluation of learning. Schools in the future will probably contain spaces that support both


Key Decision Point
(see Stage 5, Figure 34)
Percent of instruction delivered through cohort processing
What are the instructional frameworks, pedagogies, learning resources, and delivery strategies?
Percent of instruction delivered through individualization

Major Variables		
Types of spaces	• Group oriented	• Individualized
Instructional delivery	• Teacher centered	• Mediated
Curriculum	• Largely unstructured	• Structured and flexible
Equipment requirements	• Class lots	• Determined by formula or operations research*
Time of use	• Rigorously scheduled	• Flexible and variable
Importance of class size	• Very important	• Relatively unimportant

*** Usually 10 - 30% of numbers required for grouped instruction**

Figure 35. Significance of instructional and pedagogical decisions on factors pertaining to instructional spaces.

traditional educational delivery as well as spaces that support technologically-enhanced and individualized instructional delivery. The individualized areas, the classrooms of the future, will probably have to serve a variety of purposes both concurrently and over time. A number of different activity areas might be considered for inclusion in the classroom of the future -- an area which might be equivalent to two or three present-day classrooms (i.e., 150 to 225 m^2) in the smaller schools. In larger schools each of the required functions may be accommodated in spaces equivalent to today's classrooms but these large spaces should be converted to specific types of workstations.

Workstations and activity areas included in classrooms of the future, depending on the grades of students and the programs offered, might include some or all of the following kinds of spaces:

- A wet station to serve science and home economics activities.

- A dry workstation for subjects such as physics or electronics.

- A computerized workstation for subjects such as business education.

- General purpose computer stations to support word processing or computer supported instruction. There should be ample space on which to spread work.

- A large work area for project work and art (preferably near the wet workstation).

- A reading area. (This may be like a living room and designed to encourage students to relax and read.).

- Several individual workstations or carrels.

- A media center where students can watch videos or films and listen to tapes. Light control is imperative.

- A test center/conference center where students may take tests or meet with teachers or other resource people.

- A communications center where students and teachers may communicate with others located outside the immediate area. Included might be capabilities for: electronic mail, facsimile, two-way radios, telephones, and so forth. A teleconferencing facility may be provided which would allow up to five or six students and a supervisor or teacher to interact with others at one or more distant locations*. In many regards the communications center is the hub of the classroom of the future. It should link students to the schools resource center and through that center to the outside world. The communications center may also serve to link students studying at home with the learning resources available from regional centers. Teachers should have links to other teachers, to administrators, and to resources outside the classroom and school.

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*Teleconferencing facilities, and other technological tools, are probably not being used most effectively when they are used for the purpose of increasing a student catchment area in order to capture an aggregation of students large enough to justify offering a course in the traditional cohort-processing mode. Rather, these resources might be better used to link students with noted authorities in a variety of subject areas.

- Adequate storage for learning resource kits and materials. It may be that the lab would have to have space for kits supporting a variety of courses.

- Adequate storage for student materials.

- A teacher work space which is private yet affords good supervision of the lab.

The classroom of the future may grow to become the school of the future. In that case, many of the functions may be served by existing resources. For example, a library could be relied on to provide the quality spaces for reading that are specified in the reading areas.

Determination of the number of workstations required for a given student population is a matter that may be addressed through use of queuing (waiting line) theory.

Figure 36 depicts the functions and relationships that could be reflected in a classroom in the future. The diagram may also be used to describe the functions and relationships that should exist in a school. Translation of these functions into specifications for facilities is detailed in a report entitled *Distance Education: A Program and Facility Study* (HSP Humanité Services Planning Ltd., 1988).

As the use of technology increases in the educational environment, it will become increasingly more feasible to develop more and more learning resources centrally for use at decentralized sites. As a consequence, it may be appropriate to develop networks to link workstations, classrooms, schools, and delivery centers.

Summary

Appropriate uses of technology in education necessitate changes to both the way teachers go about the activity of teaching and the way students engage in the learning process. The model of the teacher as the fountain of knowledge and the students as cups (all waiting to be filled at the same time) changes in the face of technology. Technology has the potential for individualizing and customizing educational delivery to students. As technology changes the educational processes, the requirements of educational facilities also change. Classrooms and schools designed as places for lock-step processing of cohorts of students are inadequate for educational delivery systems aimed at individualizing the learning processes. Needed are flexible spaces where students can participate in a wide range of activities and draw on a wide range of information sources. Future instructional spaces should be designed around a communications corridor that links these instructional spaces to information sources beyond the walls of classrooms and schools.

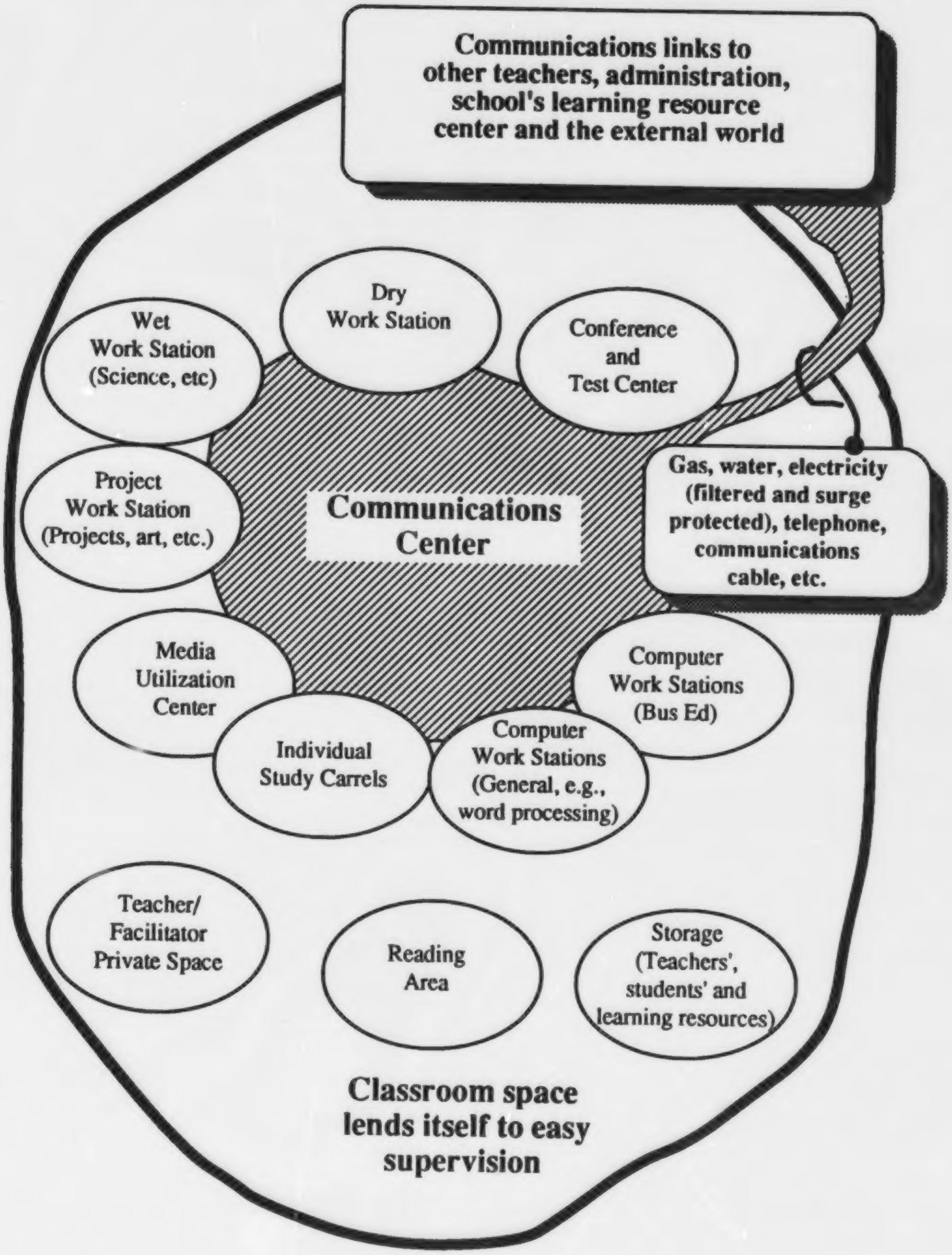

Communications links to other teachers, administration, school's learning resource center and the external world
Dry Work Station
Wet Work Station (Science, etc)
Conference and Test Center
Project Work Station (Projects, art, etc.)
Communications Center
Gas, water, electricity (filtered and surge protected), telephone, communications cable, etc.
Media Utilization Center
Computer Work Stations (Bus Ed)
Individual Study Carrels
Computer Work Stations (General, e.g., word processing)
Teacher/ Facilitator Private Space
Reading Area
Storage (Teachers', students' and learning resources)
Classroom space lends itself to easy supervision

Figure 36. Functions and relationships to be included in classrooms and schools of the future.

Chapter 11

Software Specifications for a Network-Based Learning System

At the heart of a technologically-enhanced educational delivery system is the software program that manages the curriculum and its attendant components and delivery mechanisms. Figure 37 identifies the components or subsystems that would be required in a fully-fledged network-based learning system software package.

The entire network-based learning system is built around nested curriculum networks -- programs, courses, units and lessons -- and their associated objectives. The importance of the networks lie, in part, in their ability both to provide curriculum mapping and to plan and track student paths through the curriculum.

Tightly linked to the curriculum networks are the learning resources which may take many forms (hard copy texts, computer software, audio and video media, and so forth) and these learning resources may be classified by: media type, units of measurement used in the resources, language, reading levels, content and interest areas, and learning styles. Access to the learning resources is made easy through use of the unique identification labels assigned to each lesson objective on the curriculum networks. This sophisticated resource management system makes it very easy to select appropriate materials for students in individualized programs.

A brief description of each of these yet-to-be-developed software packages is provided together with some tentative specifications for their development.

The ***authoring subsystem*** allows educators (the system managers and learning resource authors) to develop the curriculum networks and to translate them into learning resources. Many of the parameters to be managed in an authoring system are described in Step 7 of the curriculum development process outlined in Chapter 7. The authoring

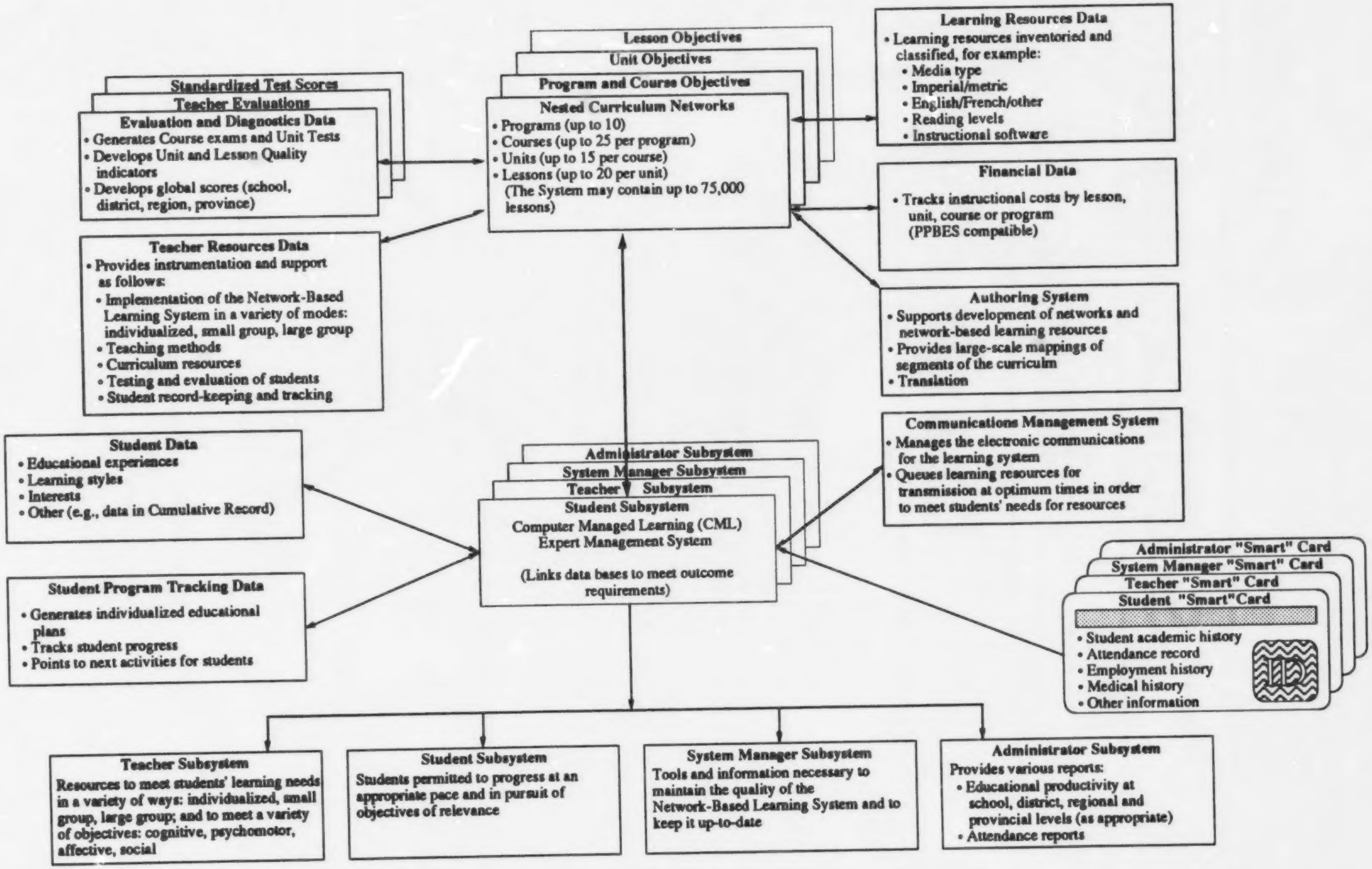

Standardized Test Scores
Teacher Evaluations
Evaluation and Diagnostics Data
• Generates Course exams and Unit Tests
• Develops Unit and Lesson Quality indicators
• Develops global scores (school, district, region, province)
Lesson Objectives
Unit Objectives
Program and Course Objectives
Nested Curriculum Networks
• Programs (up to 10)
• Courses (up to 25 per program)
• Units (up to 15 per course)
• Lessons (up to 20 per unit)
(The System may contain up to 75,000 lessons)
Learning Resources Data
• Learning resources inventoried and classified, for example:
• Media type
• Imperial/metric
• English/French/other
• Reading levels
• Instructional software
Financial Data
• Tracks instructional costs by lesson, unit, course or program (PPBES compatible)
Teacher Resources Data
• Provides instrumentation and support as follows:
• Implementation of the Network-Based Learning System in a variety of modes: individualized, small group, large group
• Teaching methods
• Curriculum resources
• Testing and evaluation of students
• Student record-keeping and tracking
Authoring System
• Supports development of networks and network-based learning resources
• Provides large-scale mappings of segments of the curriculm
• Translation
Communications Management System
• Manages the electronic communications for the learning system
• Queues learning resources for transmission at optimum times in order to meet students' needs for resources
Student Data
• Educational experiences
• Learning styles
• Interests
• Other (e.g., data in Cumulative Record)
Administrator Subsystem
System Manager Subsystem
Teacher Subsystem
Student Subsystem
Computer Managed Learning (CML)
Expert Management System
(Links data bases to meet outcome requirements)
Student Program Tracking Data
• Generates individualized educational plans
• Tracks student progress
• Points to next activities for students
Administrator "Smart" Card
System Manager "Smart" Card
Teacher "Smart" Card
Student "Smart"Card
• Student academic history
• Attendance record
• Employment history
• Medical history
• Other information
Teacher Subsystem
Resources to meet students' learning needs in a variety of ways: individualized, small group, large group; and to meet a variety of objectives: cognitive, psychomotor, affective, social
Student Subsystem
Students permitted to progress at an appropriate pace and in pursuit of objectives of relevance
System Manager Subsystem
Tools and information necessary to maintain the quality of the Network-Based Learning System and to keep it up-to-date
Administrator Subsystem
Provides various reports:
• Educational productivity at school, district, regional and provincial levels (as appropriate)
• Attendance reports

Figure 37. A depiction of the data bases and software subsystems required in the network-based learning system.

system should resemble an expert system and it must be user-friendly so that curriculum building can take place on many fronts with all of the initiatives tailored for inclusion in the overall system (i.e., locally developed and shareable courseware and learning resources). The authoring system should also have a capability for generating program-level and course-level mappings of curriculum objectives at the unit and lesson levels of specificity.

As an option, an authoring system could be designed to convert or translate the curriculum and its resources from one language or mode to another. As an example, conversions could be developed to automatically translate metric measures into Imperial measures and vice versa. In the same way language translations could be used to convert curriculum content from English text into French, or some other language.

Teacher resource data subsystem permits teachers to acquire all of the available resources needed to implement the network-based learning system in a variety of settings. For example, teachers would be able to access information pertaining to specific curriculum objectives, implementation methods, and evaluation methods as well as professional development materials.

The ***evaluation and diagnostics subsystem*** of the network-based learning system has capabilities for generating student evaluation and diagnostic information as well as utilizing the results of standardized test scores and teacher-based evaluations of students.

The ***student information subsystem*** manages relevant student information -- educational experiences, learning styles, interests, aspirations and educational goals. Information normally recorded on Cumulative Record Cards may be stored and used in the network-based learning system as the basis for automated generation of Individualized Educational Plans.

The ***student tracking data subsystem*** consists of the individualized macro and micro curriculum maps shown in Figure 23. These "strip maps" clearly show both students and teachers where each student is located in the total curriculum.

A ***communications management subsystem*** would serve to orchestrate the flow of information and resources from centralized to decentralized sites. Operating in conjunction with the student evaluation and record-keeping subsystems, this subsystem could be programmed to acquire and queue up resources in anticipation of students needing them. In the later stages of system development, the communications management system may be capable of interactive connection of decentralized users (i.e., teachers and students) to centralized resources and it may do it in real time.

Special subsystems serve the needs of students, teachers, and administrators.

The central management and control system includes four executive subsystems: a student subsystem, a teacher subsystem, an administrator subsystem, and a system manager subsystem. Each subsystem is intended to serve the needs of one of the specialized groups of users of the network-based learning system.

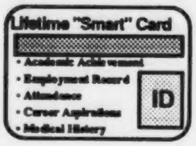
The ***student subsystem*** must be user-friendly and it should: outline the scope of programs and courses they will undertake and the criteria by which they will be evaluated; provide access to a summary of achievement to date; provide direction or guidance in choosing subsequent learning objectives, suitable learning resources in keeping with their learning styles and preferences; provide formative and summative tests of achievement based on the curriculum content being studied, and with immediate feedback of the results of performance on tests and lesson evaluations; provide a description of the prerequisite skills required in any subsequent programs; test proficiency at pre-defined checkpoints throughout the curriculum; provide review of acquired skills and proficiencies as necessary; enable progress at individualized rates by using learning resources matched to abilities, aptitudes and learning styles; highlight problem areas; and facilitate direct one-on-one assistance from a teacher or instructional aide.

The ***teacher subsystem*** should support all teacher activities and especially it should provide professional development resources and resources to meet students' learning needs in a variety of ways (e.g., individualized, small group, large group) and to serve a variety of objective types (e.g., cognitive, affective, psychomotor, and social).

The ***administrative subsystem*** provided for administrators and managers at the school, district, and provincial levels allows them to: access student achievement results (individually, or by groups) at any time; employ a planning framework into which the work of many participants may be incorporated into a significant whole; reduce major discrepancies in program interpretation in both student expectations and evaluation criteria; describe the program and learning resources to the public or other interested stakeholders; and to "tailor" courses and programs for individual students which are not necessarily bound to specific sites (i.e., classrooms) or to specific times (i.e., during regular class periods).

The ***learning system manager subsystem*** is designed to provide the learning system manager with the information needed to maintain the quality of the curriculum and to keep it up-to-date. For the learning system manager, the subsystem should provide: an authoring system that guides development of the curriculum and related resources; feedback on the efficiency and effectiveness of the curriculum design and implementation modes; mechanisms for highlighting problem areas; and, mechanisms for maintaining the curriculum at the highest possible state of currency and quality. Finally, a good learning system should encourage and facilitate cooperation among a number of different groups and specializations in activities leading to development of a curriculum -- groups and specializations such as teachers, child development specialists, learning psychologists, curriculum writers, illustrators, and others.

As an option, a ***financial data subsystem*** may capture financial information at the lesson level which may then be aggregated (by site) to the unit, course or program level. This subsystem may be designed for compatibility with a variety of PPBS models and frameworks.


Lifetime "Smart" Card
• Academic Achievement
• Employment Record
• Attendance
• Career Aspirations
• Medical History
ID

Access to the network-based learning system may be handled in a variety of ways. The simplest system would be by ***"smart" card*** -- a card similar to a bank card with the added feature of having a data storage capability so that information such as identification, academic history, attendance, employment records, medical records, and other relevant information may be stored, accessed and updated by the expert system as required.

Summary

This chapter has provided a brief description, or overview, of the specifications for the computer software required to support the network-based learning system. Inasmuch as the final operating specifications for a learning system can be developed only through field testing, detailed software specifications must evolve as the development of a network-based learning system progresses.

Chapter 12

Developing a Large-Scale Network-Based Learning System

A vision of the way that technology might be used to increase educational productivity and to enable teachers to provide more individualization of instruction is outlined in Part I. Part II, to this point, describes many of the technical aspects associated with developing, implementing and evaluating a network-based learning system. This chapter discusses some of the preliminary steps which may be taken to build a technologically-enhanced network-based learning system capable of supporting instruction in a number of classrooms, a school, a district, a region, province/state or a nation. While the network-based learning system offers many benefits to individual teachers choosing to adopt the approach to their own classrooms, its greatest efficiencies and benefits will come through large-scale implementation when the high front-end costs associated with development of the network-based curriculum and associated resources may be distributed over a wide base.

Traditionally, education has been provided to students by teachers acting as principal sources of knowledge. The large group lecture approach worked very well as long as the body of knowledge to be transmitted to students was manageable and as long as the students were pursuing common goals and objectives. Teachers are presently under great pressure in today's classrooms because the body of knowledge has grown exponentially and students no longer pursue common clusters of goals. Moreover, the student population has changed over time and has become more heterogeneous inasmuch as it includes a much higher percentage of the nation's total number of young people. As a consequence, teachers need a new set of tools which will allow them to help greater numbers of students find their way through a set of learning objectives tailor-made to their needs. The network-based learning system has the potential for providing many of these tools that the teachers now lack.

The key to a large-scale network-based learning system is the curriculum network because it provides the capabilities for: (a) labeling each curriculum objective and specifying its invariant relationship to other objectives in the curriculum; (b) using objective (i.e., lesson) identification codes as address labels for all related resources and instructional materials; (c) managing classroom instruction and students records; and (d) providing for the evaluation of students, teachers, and the curriculum.

As described in Chapter 8, a curriculum network may be implemented in a number of ways: (a) by teachers implementing the entire curriculum in regular classrooms; (b) by teachers working in teams; (c) by teachers operating in departmentalized subject areas; (d) by teachers operating from educational service centers; and (e) by students located in their homes, at their work sites, or in supervised settings. Obviously, technology has two very large roles in the network-based learning system: as a tool for use in integrating curriculum objectives into a network, and as a tool for the acquisition and management of both the learning resources and communications linkages required to deliver education in a variety of different modes.

In order that each instructional setting may have access to the widest possible range of learning resources, a second kind of network should be established -- a communications network capable of providing two-way links between points of instructional delivery and regional service centers for such things as: curriculum and curriculum revisions, delivery of instructional materials, electronic mail, and curriculum and instructional support.

When the network-based learning system is operated as a computer-based system and with full capabilities for student records management, a computer may be relied on to predict where each student will be working in the short-term and to use available telecommunication systems during slack time and down time (e.g., night-time) to acquire and queue up the instructional resources required by students for those instructional objectives which will be undertaken in the immediate future. These orders and requests may be queued up at a regional center and transmitted by the most appropriate communications channel and at the earliest opportunity. Whereas many of the instructional resources in use today would have to be transported by ground transportation, many of the instructional resources presently being developed are suitable for electronic transmission. This has an important advantage over print and film media which must be carefully catalogued and filed (and requires considerable storage space). The electronic media may be stored on tape or discs and erased after use and the tapes re-used.

A Phased Development Plan

Development of a network-based learning system intended to serve a large geographical area should be developed and tested in phases. This has the effect of reducing the overall risks in the project and of minimizing costs.

At the core of the system is the network-based curriculum and all the associated learning packages (lessons) and their supporting instructional resources. The centralized resources would include the network-based curriculum, lessons, learning resources, teacher resources, and communications links capable of delivering audio, video and digital information to the decentralized centers either by ground transportation or by electronic systems.

Any number of smaller centers could be developed to operate regionally. Through these centers, teachers and students may requisition and receive resource materials and support from the central system. Operating within the service areas of these regional centers would be regular classroom teachers and students, teachers and students in various off-campus settings, home-bound students, and isolated students or students in work places.

Operating from these regional centers might be re-broadcast capabilities, computer-based instructional programs, specially equipped trailers for optional programs (e.g., industrial and vocational programs), and various counselling and student-help services.

Alternatively, many of these services could be delivered via a geosynchronous satellite (a satellite which appears stationary with respect to a particular spot on the earth's surface) or by means of other wide-area communications techniques.

A technologically-enhanced learning system may be designed, developed, installed, and operated for one or more purposes, for example: (a) fostering educational equity, (b) increasing educational productivity, and (c) providing an educational alternative to traditional public education.

The learning system may also be designed to serve particular segments of the student population. For example, the focus could be on: (a) rural students in small schools, (b) students who have no access to schools, (c) students who have special needs (i.e., special education), (d) students in private schools and on home-study programs, (e) classrooms and schools where students want greater program choice, or (e) anywhere that there is a desire to provide individualized and customized education in order to increase productivity or to reduce costs.

Development of a fully-fledged network-based learning system may take four to six years but the work may be phased and activities carefully orchestrated so that some benefits may be anticipated before system development is entirely completed (i.e., some teachers and students will be reaping benefits). The preliminary plan contained in Figure 38 reflects the four phases

During ***Phase 1*** the preliminary specifications for an educational delivery system should be developed including specifications for: courseware, hardware, software, and human resources. Feasibility of the approach should be assessed, pilot studies should be designed, and plans should be developed for subsequent phases.

During ***Phase 2*** a number of pilot projects should be developed, implemented, and evaluated in order to obtain needed information and to adequately test feasibility of the learning system concept.

Phase 3 involves development of a prototype K-12 educational delivery system (curriculum, classroom management systems, and technological infrastructure) sufficiently large to allow testing of all of the basic design concepts. Phase 3 should terminate with a set of specifications for a full-scale system.

Development Activities	Phase 1	Phase 2	Phase 3	Phase 4
Needs assessment and interfacing with other educational institutions	Yes	Yes		
Resource inventory	Yes	Yes		
Curriculum design				
• manual mode	Yes			
• automated mode		Yes	Yes	Yes
Teacher and student learning resources development				
• manual mode	Yes			
• automated mode		Yes	Yes	Yes
Software development				
• authoring system				
• curriculum mapping	Yes	Yes		
• instructional resource development		Yes	Yes	Yes
• resource management		Yes	Yes	Yes
• producing student Individual Educational Plans			Yes	Yes
• providing student tracking				
• manual	Yes			
• automated		Yes	Yes	Yes
• student evaluation processes			Yes	Yes
• curriculum evaluation processes			Yes	Yes
• financial data and reports (optional)			Yes	Yes
• communications management and delivery	Yes	Yes	Yes	Yes
• controlled access ("smart cards")			Yes	Yes
Learning system acquisition				
• manual modes	Yes	Yes		
• automated and interactive modes				
• via schools or regional centers			Yes	Yes
• via homes				Yes
Reporting systems				
• teachers		Yes	Yes	Yes
• students	Yes	Yes	Yes	Yes
• system managers			Yes	Yes
• administrators (school, district, region)				Yes
Facilities (renovated or new)		Yes	Yes	Yes
Training programs				
• curriculum design	Yes	Yes	Yes	
• implementation strategies	Yes	Yes	Yes	Yes
Export products				
• curriculum		Yes	Yes	Yes
• system software			Yes	Yes
• educational service			Yes	Yes
Feasibility assessments	Yes	Yes	Yes	

Figure 38. A plan for phased development and implementation of a learning system.

Phase 4 is devoted to acquisition, installation, testing, and operation (and modification as necessary) of a fully-fledged learning system.

Figure 38 identifies a number of activities which should be completed during development of a large-scale learning system. Some of these activities span two or more phases.

Needs assessment. Needs assessment entails definition of the needs to be met by a learning system with the capabilities described in previous chapters. Satisfying the identified needs becomes the mission statement for the project. Ideally, the needs assessment should be completed early in the project in order that the overall system design may proceed in an orderly fashion.

Accordingly, it should be important to: identify the need for a learning system in terms of students by: age, grade, geographical distribution, and program requirements; identify interface points with all post-secondary institutions; and to develop a mission statement to guide further development of a learning system.

Resource inventory. Prior to any major development of a learning system, it is imperative that an inventory of resources should be completed. The completed inventory should be able to detail all of the resources (hardware, software, courseware, human resources, and other) that may be drawn upon during the course of the project. Moreover, for each resource, there should be a statement of roles and responsibilities so that it is clearly understood how the resources may be used.

Curriculum design. Technology fosters individualization and customization by enabling things (e.g., the curriculum) to be broken into many pieces and to be reassembled in a variety of new and different ways. Before a curriculum can be technologically enhanced, it must be modularized and broken down into many small pieces. These pieces may be reassembled into tailored programs. For maximum effectiveness, courses consisting of 10 to 15 units should be further divided into 100 to 200 specific learning objectives per course. Learning resources may then be developed and associated with these specific objectives. The curriculum design and development may occur in order to meet two different needs -- manual operation of pieces of the learning system and fully automated operation.

Manual mode. Use of materials in a manual mode should serve to confirm that automated mode specifications are appropriate.

The first step is to modularize selected curriculum programs to a level where objectives can be transmitted in one or more mediated forms (audio tape, video tape, floppy disk, learning kit, etc.) and to develop self-teaching packages around these objectives. The next step is to pilot test the self-teaching materials in a manual mode (i.e., limited use of computers in areas such as student record-keeping and inventory control of learning resources as well as communication networks).

Automated mode. In the automated mode most routine and repetitive activities will be managed by the system software (e.g., student program planning and preparation of Individualized Educational Plans, student tracking, resource management, testing, curriculum evaluation, and so forth). Pilot testing of the self-teaching materials developed to date in a semi-automated mode should continue (i.e., use of computers in areas such as student record-keeping and inventory control of learning resources and use of communication networks to deliver some resources to schools and classrooms). Finally, the developed materials should be introduced into a fully automated system.

Learning resource development for teachers and students. The roles of teachers and students should change in a technologically-enhanced learning system. As a consequence, there is a need for learning resources for both. For teachers, the learning resources should provide the sorts of information they require in order to implement the system and to facilitate individualized and customized student learning. For students, the learning resources should help them to use the learning system.

Initially, the learning system should operate in a manual mode. Later, as the technological enhancements are installed, the system should operate in an automated mode.

Phase 1 resources should focus on helping students and teachers make the transition from cohort-processing to individualized and independent modes of instruction and instructional delivery while in a *manual* mode of operation.

Beginning with Phase 2, resources should be focused on helping students and teachers make the transition from cohort-processing to individualized and independent modes of instruction and instructional delivery while in an *automated* mode of operation.

System software development. Development of a learning system entails development of system-level or executive software needed to manage the system. While the software may be expected to be somewhat complex, it will be highly generalizable and well suited as an item of export to any jurisdiction seeking to develop its own learning system. The software packages include an executive software system and a number of subsystems.

System executive software development which consists of development of the software that will enable computers to manage many of the operations in a learning system. Specifications for the system software should be developed on the basis of operation in the manual mode. These specifications should be further translated into prototype software for use on a limited scale in a prototype system. Evaluation of the prototype software should lead to development of operational versions which may be used in Phase 4. Within the executive software package will be a number of important software subsystems:

- *Authoring subsystem.* Develop the specifications for the authoring subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode. Use the developed subsystem in on-going activities. Included in the authoring subsystem will be the following functions:

    - *Curriculum mapping.* Develop the specifications for the curriculum mapping subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Instructional resource development.* Develop the specifications for the instructional resource development subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Translation.* Develop specifications for automatically translating curriculum and learning resources on the basis of units of measure (e.g., metric to Imperial) or language (e.g., English into a second language).

- *Resource inventory and management.* Develop the specifications for the resource inventory and management subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Production of student Individual Educational Plans subsystem.* Develop the specifications for the subsystem required to produce Individual Educational Plans and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Student tracking and record-keeping subsystem.* Develop the specifications for the student tracking and record-keeping subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Student evaluation processes subsystem.* Develop the specifications for the student evaluation subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Teacher evaluation processes subsystem.* Develop the specifications for the teacher evaluation subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Curriculum evaluation processes subsystem.* Develop the specifications for the curriculum evaluation subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Financial data and reports subsystem* (optional). Develop the specifications for the financial reporting subsystem and validate the processes and procedures in a manual mode. Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Communications management and delivery subsystem.* Develop the specifications for the communications management and delivery subsystem and validate the processes and procedures in a manual mode.

Develop an automated subsystem for meeting the specifications and validate the processes and procedures in a semi-automatic or fully automatic mode.

- *Controlled access ("smart cards") subsystem.* Assess the feasibility of "smart card" access to the subsystem and the possibility of linking to a student registry for various administrative functions, for example establishing student grants.

Once these software subsystems have been initially developed and tested, it then becomes possible to develop specifications for further development.

Learning system acquisition. Acquisition of a large-scale learning system entails several discrete stages: pilot testing key concepts and ideas, development and testing of a prototype system, and finally, specification, acquisition, installation, testing, and operation of a total learning system.

Basic learning system. The system should be built and tested first in a manual mode before attempts are made to automate significant portions. Develop the operating requirements and specifications for first a manual and then an automated learning system. Developmental stages include:

- A pilot system (develop and install pilot systems and test as appropriate);

- A prototype system (acquire, install and test a prototype system); and

- A total system (acquire, install, test and operate a total learning system).

The learning system may also be designed to support a number of educational needs.

Via schools or regional centers. Develop and test specifications for manual operation from schools or regional centers. Develop and test specifications for automated operation from schools or regional centers

Via homes and other. Develop and test manual operation from homes or other points of access. Develop and test automated operation from homes or other points of access.

Reporting subsystems. As the learning system begins to operate and as students begin to flow through the system, there will be the need for reports by many of the participants and players, for example: teachers, students, system managers, and administrators. This system will provide these reports.

Facilities. Schools have been designed to support cohorts of students: each cohort served by a teacher. The learning system has the capability of serving individual students in individualized, independent and customized study programs. As the role of students and teachers change, so will the learning spaces. Accordingly, the ideas contained in the report entitled *Distance Education: A Program and Facility Study* (HSP Humanité Services Planning Ltd., 1988) should be validated in practice through pilot projects and test cases.

Human resource development. Traditionally, teachers have been prepared to provide instruction in group settings. Few have any training or experience in areas of curriculum development or educational delivery in an individualized or customized mode. Accordingly, there will be a significant need for pre-service, in-service, and internship programs as a part of development of a learning system. In each case the sequence of events should be as follows:

- Specify pre-service/in-service/internship requirements for instructional delivery,

- Develop programs,

- Implement the programs, and

- Induct the new graduates into the learning system.

Export products. When completely developed, there should be a number of by-products of the learning system which could be exported. Specifically, it should be possible to export individualized program and curriculum materials and resources, system software, and educational services. Products available for export during the later phases of the learning system development should include: modularized curricula and associated learning resources; system software; and, educational services.

Feasibility assessments. Test the feasibility of learning system specifications and its intended application in each phase of development and adjust long-range plans accordingly. A feasibility assessment model suitable for learning systems is included as Appendix 2.

The following brief descriptions and graphical representations of a learning system as it undergoes development may further clarify the phased development of a large-scale learning.

Phase 1

Phase 1 involves development of a small number of network-based courses, and together with associated learning resources, they could be tested in real situations -- in regular classrooms, in independent study, in small schools as a way of providing enriched programs, and so forth. More specifically, this entails development of a number of network-based courses, development of the lesson plans, development of the supporting instructional resources, development of the resource management system, and development of the student and curriculum evaluation mechanisms. Because many of these materials will require pilot testing, classroom teachers should use the instructional materials and student record-keeping systems in a manual mode as a means of de-bugging both the instructional materials and the management systems.

Phase 2

The Phase 2 system development entails further curriculum development together with some preliminary attempts at automation of both curriculum development and instructional delivery. Mobile labs may be utilized to support some of the more practical programs in the more sparsely settled areas (e.g., industrial arts, home economics, trades).

Figure 39 depicts the second phase configuration of the network-based learning system. The tested curriculum, instructional materials, supporting resources, and management systems are installed in a centralized computer. Two-way communications links are established to a number of regional centers. The primary intent of this phase is to test the communications links between the regional centers and the central system.

Phase 3

The third phase (Figure 40) entails automation of much of the resource management, record-keeping and evaluation functions and the extension of the curriculum into classrooms -- still in the manual mode. Phase 3 calls for decentralization of much of the network-based learning system curriculum and software to regionalized centers. Through decentralization students' access is made easier and communications costs are reduced because of the shortened communications lines for students.

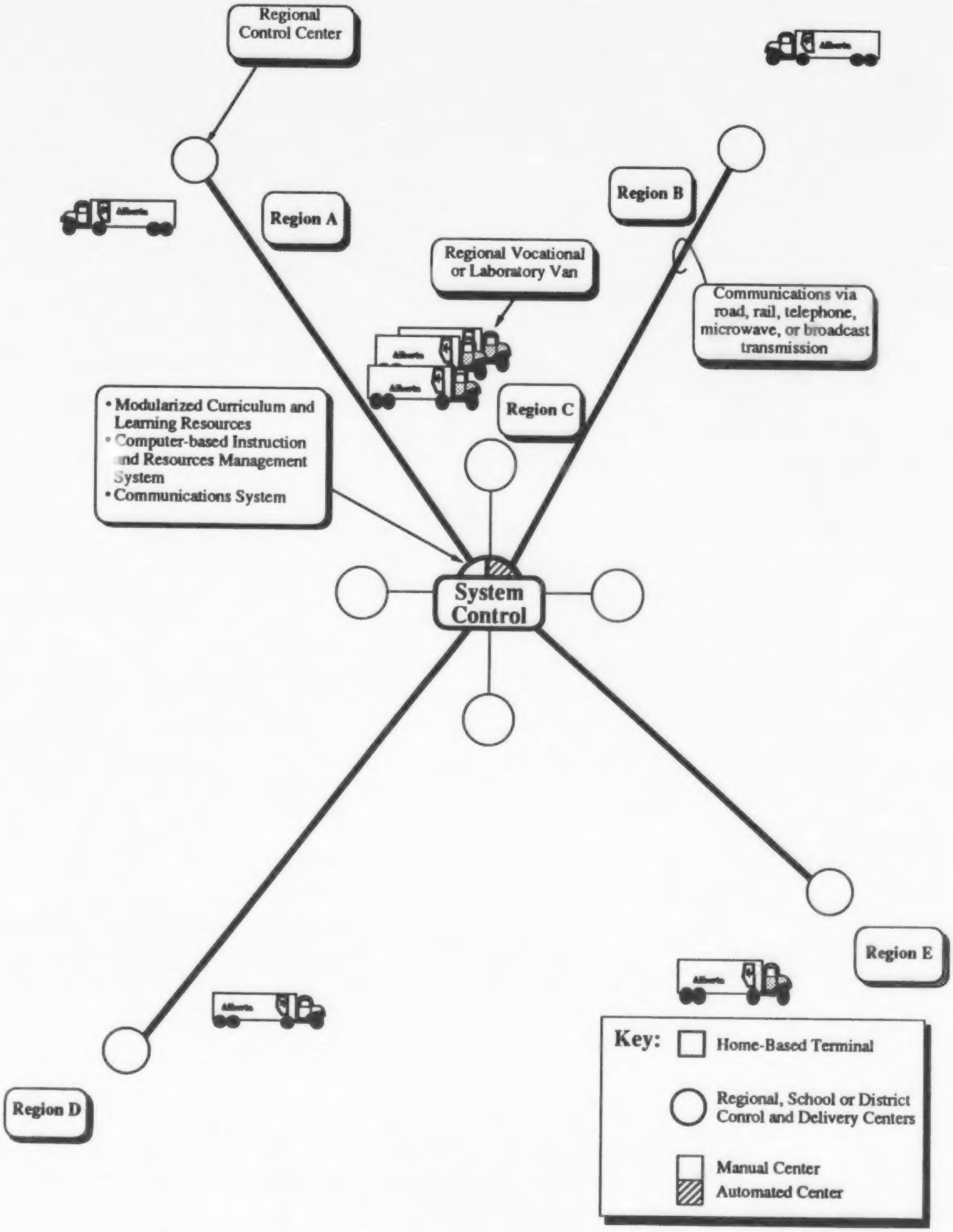
Phase 4

In the fourth phase (Figure 41), classrooms and remote learning sites are coupled into the communications links, as appropriate, so that more teachers and students can enjoy the full benefits of the network-based learning system. Full use is made of ground transportation, electronic communication links, satellites or other mass coverage media, and mobile labs. The Phase 4 system represents a fully developed, interactive system capable of linking students and instructional resources (including support for teachers) that are grouped in classrooms or separated by great distances.

A number of by-products of the Phase 3 and Phase 4 systems would be marketable, including: courseware and learning resources, network-based learning system software, and instructional services.

Summary

Appropriate uses of technology have been achieved by an organization when technology has changed the way its work is organized and carried out. The network-based learning system provides the tools needed to support substantial individualization and customization of education. While successful small projects may occur in classrooms, and teachers in these classrooms may develop informal communications networks to facilitate sharing of resources, the greatest impact will occur when larger projects are planned and implemented. This chapter provides a skeletal plan for development of a fully-fledged network-based learning system over a period of four to six years.



Regional Control Center
Region A
Region B
Regional Vocational or Laboratory Van
Communications via road, rail, telephone, microwave, or broadcast transmission
• Modularized Curriculum and Learning Resources
• Computer-based Instruction and Resources Management System
• Communications System
Region C
System Control
Region D
Region E
Alberta
Key:
Home-Based Terminal
Regional, School or District Conrol and Delivery Centers
Manual Center
Automated Center

Figure 39. A depiction of a prototype educational delivery system (Phase 2).

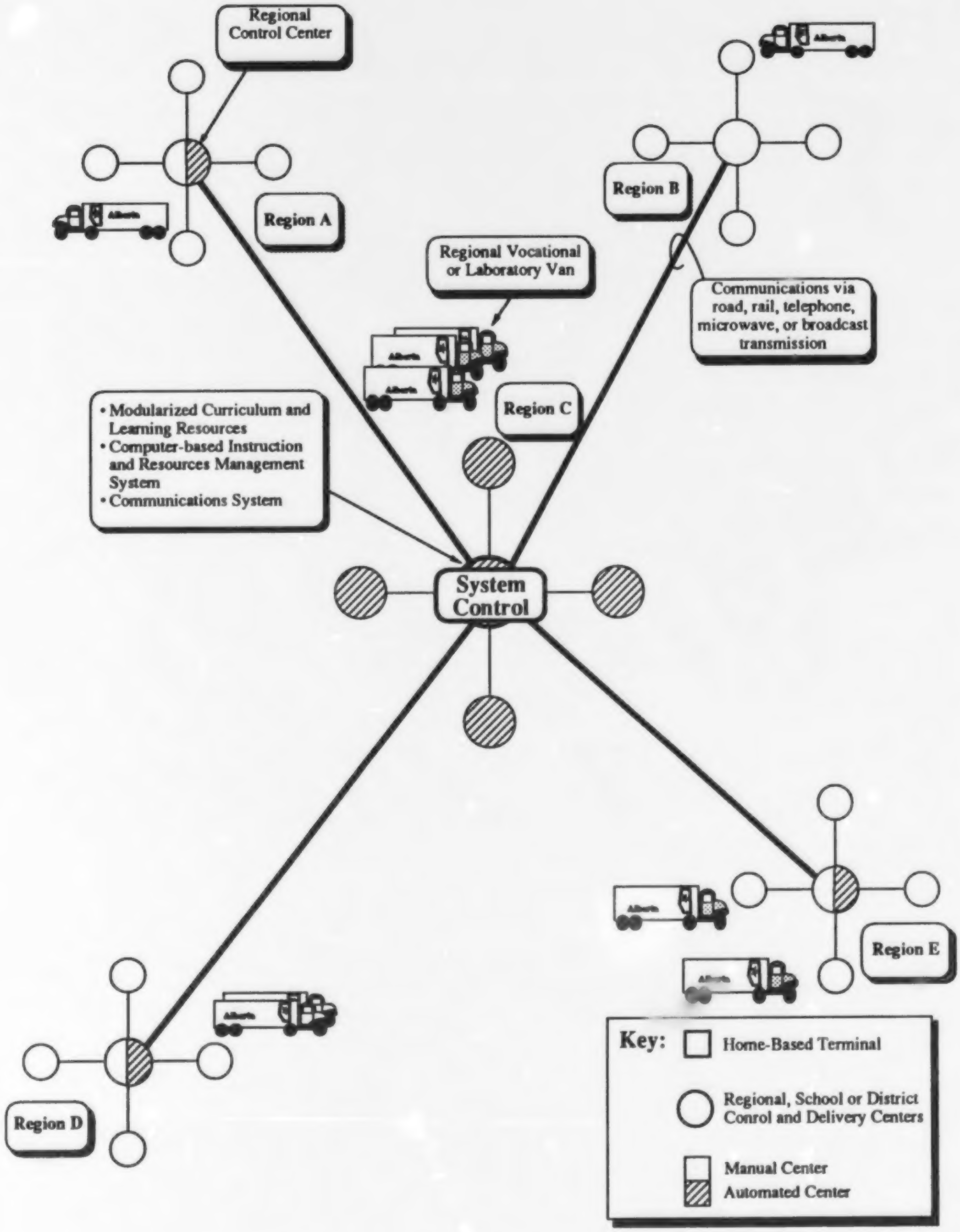

Regional Control Center
Region B
Region A
Regional Vocational or Laboratory Van
Communications via road, rail, telephone, microwave, or broadcast transmission
• Modularized Curriculum and Learning Resources
• Computer-based Instruction and Resources Management System
• Communications System
Region C
System Control
Region E
Region D
Key:
☐ Home-Based Terminal
○ Regional, School or District Conrol and Delivery Centers
☐ Manual Center
▨ Automated Center

Figure 40. A depiction of a semi-automated educational delivery system (Phase 3).

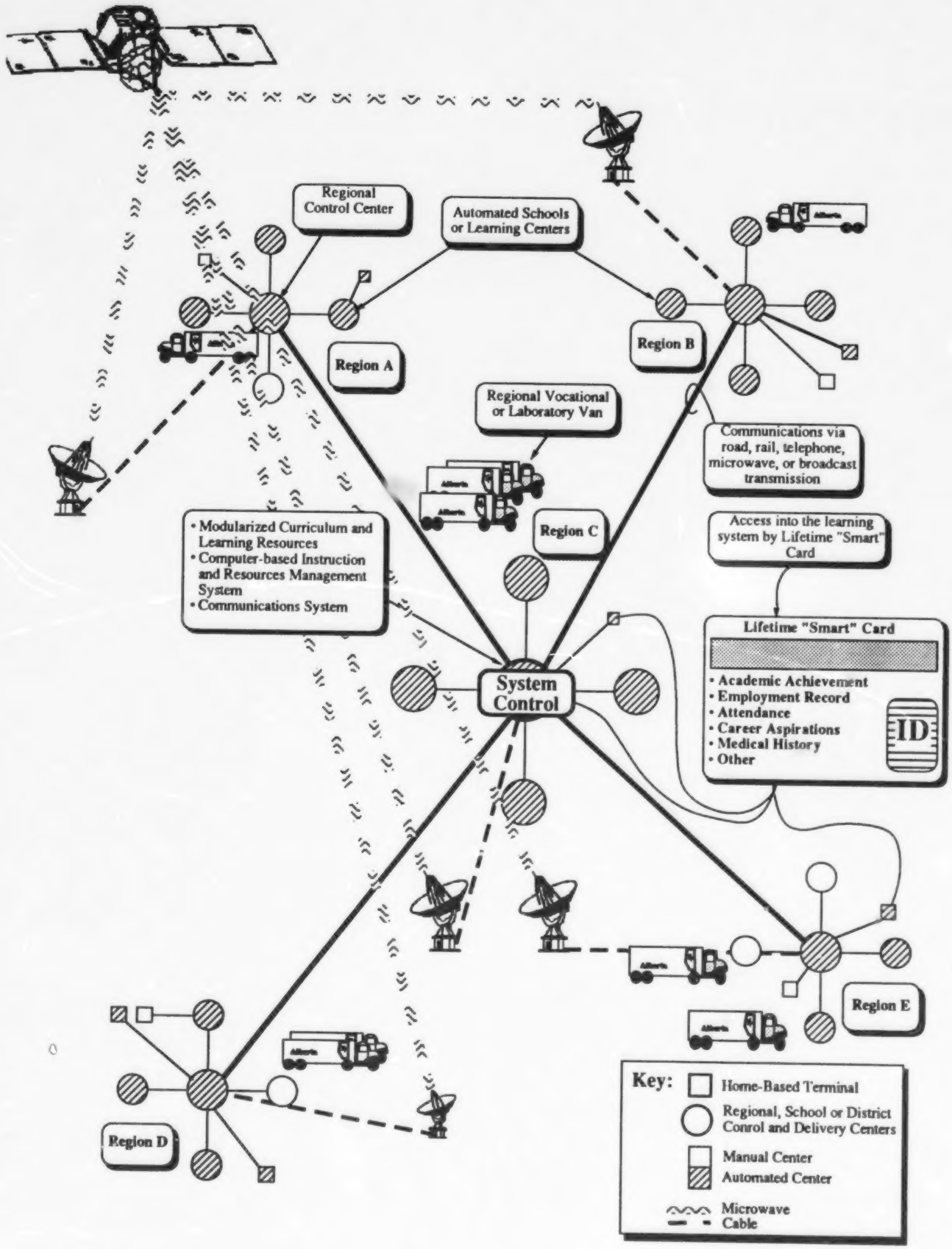

Regional Control Center
Automated Schools or Learning Centers
Region A
Region B
Regional Vocational or Laboratory Van
Communications via road, rail, telephone, microwave, or broadcast transmission
Access into the learning system by Lifetime "Smart" Card
Region C
• Modularized Curriculum and Learning Resources
• Computer-based Instruction and Resources Management System
• Communications System
System Control
Lifetime "Smart" Card
• Academic Achievement
• Employment Record
• Attendance
• Career Aspirations
• Medical History
• Other
ID
Region E
Region D
Key:
Home-Based Terminal
Regional, School or District Conrol and Delivery Centers
Manual Center
Automated Center
Microwave
Cable

Figure 41. A depiction of a fully-fledged educational delivery system (Phase 4).

Epilogue

If, as Fraser et al (1987: 148-149) concluded, "... by the fifth grade, the worst Asian classes... exceeded the best American class..." and if excellent educational achievement is a key to entrepreneurship, leadership, and competitive free trade, then incremental improvements in North America's educational systems will not suffice. Needed are some quantum gains in educational productivity.

The probability of achieving these quantum gains through the cohort-processing that occurs in most of today's classrooms is low. Teachers in cohort-processing modes usually focus on the average level of achievement but end up paying undue attention to the disruptions caused in classes by those who are performing below the average and are having difficulty or by those capable of performing above the average but don't because they lack motivation. Needed are educational delivery systems that meet individual needs (not the average needs of cohorts or groups).

While most of the philosophies of education espoused by teachers and administrators place emphasis on the individual needs of students, the sad fact is that the philosophies are seldom translated into practice. And not because the proponents of the philosophies aren't serious about them. Teachers have not been provided with the tools needed to manage individualized or independent instruction.

The keys to individualized and independent learning are classroom management tools and resources which: (a) track students' progress, (b) point students to next objectives, and (c) manage the necessary learning resources. With these tools available and working well, teachers are freed to facilitate learning and to ask the probing questions of students which encourages them to analyze, synthesize and evaluate the information they acquire.

The network-based learning system embraces technology and may be regarded as one tool that is capable of meeting most of the classroom/instructional management needs of teachers today and these network-based learning systems may be developed by teachers for single classrooms, or through the collective efforts of many educators working in schools, districts, regions, states or provinces.

This book takes a look at "what is" in order to get a glimpse of "what might be". In Part I it is noted that education and technology seem to be at a crossroads and a new educational direction should be chosen. In Part II a choice is provided -- that choice being to undertake the design and development of a large-scale, technologically-enhanced learning system. Though such a learning system may still be a long way in the future, if this book has served either to hasten its arrival or to stimulate discussion about education in the future, then it has served its intended purpose.

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Appendix 1

Educational Facilities

Designing to Enhance Learning and Human Performance*

It has been said that first we shape our buildings and then they shape us. For schools this is very significant because so many of the attributes of educational facilities have a potential for either aiding or inhibiting learning and human performance. This paper identifies a number of these attributes that may influence learning and human performance. Careful attention to these attributes may enable educators and educational facility planners to plan and design educational facilities that are more productive -- to plan and design facilities that enhance learning and human performance.

Our earliest ancestors lived and worked outdoors where the quality of air and water was constantly rejuvenated and purified through the combined effects of air, water, sunlight and plants interacting with each other. Because of wide variations in these environmental variables, these ancestors learned to build dwellings in order to protect themselves from environmental extremes.

While affording protection from the elements, there are reasons to believe that buildings -- especially school buildings -- are not neutral with respect to their effects on learning and human performance. As an example of a building-induced impact on occupants, the confined air within buildings is not subject to the same rejuvenation or purifying processes available in nature. As a consequence air in buildings may contain impurities, it may lack adequate humidity, and the oxygen content may be altered and all of these factors contribute to the comfort level and to how people feel.

It is possible to identify three classes of facility-related factors that may have an effect on learning and human performance: perceptual factors, individual factors, and program factors. The **perceptual** classification includes those factors that are received or internalized by people on the basis of hidden or subtle messages -- messages which may be perceived through not only the five senses, but through some additional sixth sense. **Individual** constraining factors include those factors normally included in the domain of human performance analysis or ergonomics. Individual constraining factors are perceived through the five senses. The **program** constraining factors are those which inhibit or interfere with program planning and delivery. Table 1 identifies many of the constraining factors contained within these broad classifications. Each of these factors should be considered during the design phase of new buildings and during the planning phases for modernization and renovation projects.

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Perceptual Constraining Factors

Perceptual factors include the **building design statements** or messages that the buildings transmit about themselves. The building designs themselves attest to the fact that the buildings are not neutral -- indeed, the building is a message. Consider the statement made by buildings built to stand tall in the face of the blazing sun of southern summers or the biting cold of northern winters. Are they not (at least in some sense) built to express defiance of the elements of nature. When we air-condition or heat buildings in order to maintain air temperatures within a narrow band, with little regard for energy conservation or ecological considerations, isn't a statement being made about our regard, or disregard, for nature and her resources? What message will our children learn?

This is a far cry from the way buildings are built in other parts of the world. For example, in some instances temperature extremes are controlled to an acceptable degree in hot climates by providing operable windows and awnings, transom windows connecting rooms to systems of hallways and ducts that allow internal air to flow and to equalize the differential air pressure effects produced by air flowing around buildings. Chimneys may be used to move air vertically -- again using the natural effect of warm air rising. The effects of cold can be minimized by providing shelters and windbreaks and by capturing and using solar or environmental heat. Perhaps the temperature variability in these naturally tempered environments will be greater than is the case in artificially temperature-controlled environments but the buildings would be perceived to be in greater harmony with nature.

While most new buildings are built to be obstacle or **barrier free** and user-friendly and capable of accommodating handicapped people, some spatial impediments may remain. For example, light switches and door-operating equipment may be at inappropriate heights for some building occupants. To left-handed, visually impaired or hearing impaired people, many buildings may not be entirely user-friendly. It is also important to note that schools are to be barrier free and user-friendly, not only for the benefit of the students, but also for teachers, parents and school visitors.

Access to educational spaces usually occurs at fixed times and it is denied at most other times. This inconvenience certainly has an effect on users who are forced to adjust their schedules to the access times of the educational spaces they want to use. Technology may be of use in developing mechanisms capable of allowing for controlled entry and building use.

Spaces may also be considered in terms of their being **public or private**. Students may need access to private space and equipment in order to explore their capabilities and to take some risks without observation or fear of ridicule for failure. Educational spaces should accommodate these demands. Students also need spaces into which they can periodically withdraw. To be under constant observation may produce stressful side effects. Similarly, teachers need private space where they can work and be free from interference by others. Indeed,

Table 1. Facility-Related Factors With a Potential to Constrain Learning and Human Performance.

Perceptual
(Hidden messages)

- Building design statements
- Barrier-free messages
- Accessibility
- Spatial attributes
  - Public/private
  - Active/passive
  - Scaled to users
  - Capacity (psychological)
  - Assembly-line ethic
  - Age and condition
  - Perspective
- Aesthetics

Individual

- Physical factors
  - Radiant energy
    - Light (quality, levels, glare, contrast, aesthetics)
    - Electromagnetic
    - Soft X-rays
  - Color
  - Noise
  - Temperature
  - Vibration
  - Air quality
  - Workspace
  - Equipment
    - simple/complex
- Organizational factors
  - Nature of work group
  - Extent of supervision
- Social needs
- Physiological factors
  - Height
  - Weight
  - Motor capability
  - Handedness
  - Length of reach
  - Speed
  - Dexterity
  - Hearing
  - Vision
  - Age
- Idiosyncratic factors
  - Skill
  - Motivation
  - Attitudes
  - Needs
  - Memory span
  - Intelligence
  - Sensory capability
  - Experience
- Task-related factors
  - Types of tasks
    - Simple tasks
    - Complex tasks
    - Vigilance tasks
    - Control tasks
  - Emergency behavior
  - Isolated and infrequent acts
  - Effects of operator incapacity
  - Time availability
  - Nature of activity
    - Discrete
    - Continuous

Program

- Technological factors
  - Low technology (high touch)
  - High technology (low touch)
- Flexible spaces
- Built-in communications channels
- Student processing mode
  - Cohort
  - Individualized/ customized
- Learning styles
  - Concrete/abstract
  - Visual/auditory/ tactile
- Physical plant as classroom

Other

- Safety
- Operation, maintenance and building security
  - "Smart card" access
  - Robotics
  - Automated plant management
- Linkages with other relevant agencies

few other professionals work in environments as devoid of private space as do teachers in most schools today.

There is also a need to consider space as being suited to **active or passive** activities. Students need access to both.

Spaces should be **scaled to the users**. Perhaps kindergartens should be scaled to be significantly different from secondary schools -- window sills, light switches, cupboards, and door hardware may all be located differently. Many of the physiological factors included in the "Individual" classification in Table 1 merit consideration when scaling spaces to users.

While space allocations, on a per pupil basis, are probably adequate in most areas, there are hints that anxiety levels of building occupants increase when buildings are operated at or near maximum **capacity**. Buildings may be psychologically full at approximately 80 to 90 percent of actual maximum capacity.

Instructional spaces often convey the **mass production, assembly-line ethic**. Classrooms are usually standardized and exhibit an institutional nature. The "psychological space" of both teachers and students is subject to rude interruptions by intercom messages (the "talking" wall) and other sorts of intrusions. Somehow educational spaces must be designed to fit many different grouping patterns with the ability to change from one grouping strategy to another taking only moments.

The **age and condition** (degree of maintenance) of facilities may be important. Past generations received their education in some rather primitive educational settings while the more excellent facilities we enjoy today do not seem to be able to guarantee high educational performance. Perhaps the age and condition of school facilities are only important if the facilities are perceived by the occupants as being inferior to neighboring facilities by the choice of others or by inaction. Either way students get a message about their importance and the priority afforded to education within the community and by its leaders.

While out of doors, one's **perspective** stretches from the immediate surroundings to the horizon. To some extent visual relaxation follows a shift in the vision field. At the same time the more distant views provide information about such things as the weather and the time of day. Built environments that lack opportunities for their occupants to shift perspectives are depriving them of useful information and meaningful and relaxing breaks from routines.

The **aesthetics** of schools and school sites becomes a statement about the value and position of education within a community. Inasmuch as schools are prominent institutions in all communities and the only institution in many communities, great care should be taken to ensure that the aesthetics of schools and school sites adequately reflects the importance placed on education.

Individual Constraining Factors

Human factors analysis or ergonomics has grown extensively since World War II and deals with a number of factors that contribute to human performance. Included among these factors are: physical factors; organizational factors; social needs; physiological factors; idiosyncratic factors; and task-related factors.

Physical factors include many factors which, while routinely addressed in facility designs, also require some special consideration.

Radiant energy includes all bands of electromagnetic energy, light energy (ultraviolet, visible, and infrared) and short wave radiations such as X-rays.

Natural light includes ultraviolet radiation, radiation in the visible range and infrared radiation and these are more or less uniformly distributed in terms of power and, when viewed in its totality, natural light appears to be white. **Artificial light** (especially fluorescent light) is composed of spikes of energy at discrete frequencies (narrow bands of color) such that when they are combined they appear to be white. The best evidence that white light is a mixture of colors is found in a television set where all of the colors of the rainbow (including white) are created by emissions from electron guns exciting three phosphors (red, green and blue) on the face of the picture tube. Beyond enabling vision, light has some additional interesting effects on people. Ultraviolet light promotes synthesis of vitamin D in the skin and prevents rickets. Bathed in blue light for a few days, babies overcome the effects of hyperbilirubinemia. Preliminary research suggests that prolonged exposure to trace amounts of UV in the near region (i.e., UVA with wavelengths of 320 - 400 nanometers) may contribute to reductions in the development of dental cavities and improvements in attendance of elementary school children (Wohlfarth, 1986). Beyond the quality of the light source, well-designed lighting systems should be able to meet standards in four additional areas: light levels, contrast, glare and aesthetics. With the increased incidence of computer displays, lighting system design is further complicated because the working surfaces may be vertical as well as horizontal (computer screens or writing surfaces) and markedly different in reflective characteristics (e.g., shiny glass screens or dull paper). Indeed, the problem becomes even more complicated because some computer displays employ liquid crystal devices that require light to be seen (the displays do not emit light).

Electromagnetic radiation outside the visible light range is omnipresent and its effects are essentially unknown. Microwave ovens are powered by electromagnetic radiation at frequencies with wavelengths on the order of 25 to 50 centimeters (wavelengths such that the energy penetrates deep within objects placed in the ovens). At lower frequencies (e.g., television and radio broadcast frequencies) electromagnetic waves are much longer (e.g., 1 - 100 meters) and tend to pass through living tissue with seemingly little effect. The fact of the matter is that the effects are not known with certainty. An exploratory study by Ingraham (1983) did find some significant differences in the behavior of children under electromagnetically shielded fluorescent lamps when compared to children under similar unshielded lamps. Likewise, the effects of very low frequency electromagnetic radiation of the sort emitted by high voltage power lines is essentially unknown. As electronic equipment is squeezed into classrooms and work stations and electromagnetic radiation levels rise, electromagnetic effects on people and adjacent equipment should be monitored.

There is a potential (however small) for soft **X-rays** to be emitted by devices that emit electron beams which are accelerated by high voltages. Examples include television picture tubes and fluorescent lamps.

Color has been found to have subtle effects on people. In recent studies (Wohlfarth, 1986: Sydoriak, 1987) warm colors were associated with slightly elevated blood pressure readings in children while cool colors were associated with slight drops in blood pressure. These researchers concluded that warm colors may be of use in stimulating activity while cool colors may foster relaxation. As a practical example, a library with a cool color scheme (primarily shades of blue) was found to be significantly quieter that an identical library decorated with vivid warm colors.

Temperature has a marked effect on people. Most people are comfortable working within a temperature range from 65°F to 80°F. Cooler temperatures are preferred for sleeping and both ranges are shifted by humidity and air movement.

Noise can have an effect on people. Background noise levels can mask sounds and interfere with aural perception. This is important inasmuch as background (white) noise is often used to mask other sounds in large-area work stations. Sound can also be affected by reflections and reverberations to the extent that normal hearing is inhibited. This is an especially important factor to consider when developing spaces for hearing impaired people -- for them the reflections and reverberations completely mask or distort useful sounds.

Vibrations may also affect people, often by elevating anxiety levels. Vibrations most often emanate from nearby traffic or from rotating machinery in buildings.

Air quality may be assessed on three dimensions and deviation from acceptable norms on any of the dimensions (humidity, pollutants and composition) may have adverse effects on building occupants. Low humidity tends to contribute to dry skin and respiratory irritations. Pollutants (tobacco smoke, combustion products, organic compounds, microorganisms, particulate matter, and radon gas) destroy the quality of the air we breathe. Legionnaires' Disease is one example of airborne organisms causing problems. Air composition is important and without adequate volumes of make-up air, fuel-burning heating systems and dense occupancy levels may deplete oxygen levels and/or increase the levels of noxious gases in the air. Both are unsatisfactory.

The nature of **work stations and equipment** (whether it is simple or complex) are other factors that determine how individuals will respond in any given setting. In many cases clearly defined (marked) spaces can provide cues to users which suggest the correct (appropriate) activities that should occur in the space.

Organizational factors address issues such as the nature of the work group and the extent to which supervision is a requirement. Educational work groups vary from large groups to individual activities. For most schools the ability to supervise students is a priority. Accordingly, ease of supervision should be considered in the building design. Ironically, easily supervised space is often perceived as being institutional or having "jail-like" qualities.

Social needs are best described as the needs that people have for interaction with others. Facilities that lack spaces for socialization are perceived as being very institutional. For students in most schools, socialization space is missing. Outside of classrooms, there are few spaces where students may simply sit and chat -- most must resort to sitting on hallway floors or congregating in washrooms.

The **physiological, idiosyncratic** and **task-related** sets of factors identified in Table 1 are extremely important to the design of user-friendly facilities. Among the **physiological factors** which should be addressed when designing educational facilities are: height of the users or occupants, weight, motor capability, handedness, length of reach, speed, dexterity, vision, hearing, and age. Like the physiological factors, the **idiosyncratic factors** are highly variable among people and include: levels of skill, degrees of motivation, attitudes, individual needs, memory span (both short and long term), innate intelligence, sensory capability, and experience. The nature of tasks or activities to take place in a space or on a piece of equipment also has an impact on design. **Task-related factors** include: types of tasks (simple, complex, vigilance or monitoring, control), need for emergency behavior, extent to which tasks are isolated or infrequent, effects of operator incapacity (e.g., need for fail-safe mechanisms), time availability for tasks, and the nature of the task or activity (discrete or continuous).

Program Constraining Factors

Buildings should be designed and built with a number of other factors being taken into consideration, including technology, student processing modes and the learning styles of students. These factors have a significant potential for influencing the nature of programs that are offered. While each of these factors may interact with other variables, they are considered independently.

Technology includes the tools (hardware, software, peopleware) and information for planning, delivering and evaluating educational programs. In low technology settings, teachers are very directly involved in the process of transmitting knowledge. At the opposite end of the continuum, teachers are less involved in the transmission of knowledge but more involved in facilitating learning. At the low technology end of the continuum, there will be limited amounts of individualization, group processes will prevail. At the high technology end of the continuum, learning may occur in individualized, small group or large group settings. As a consequence, and if technology is to flourish, spaces must be flexible (i.e., convertible, versatile and expandable/contractible) and easily converted to suit different grouping requirements. Within the school there should be a network of communication lines (in conduits or raceways) capable of linking individual work stations with a central resource center and this resource center should be connectable to external information centers. The conduits and raceways should be large enough and widespread enough to handle considerable change and expansion over time. When a facility lacks in its ability to accommodate a communications network or when the instructional spaces are inflexible, educational programs are constrained. There is also a high need for electrical power to individual work stations. Because of the sensitivity of much of the electrically operated equipment (e.g., computers), there is a need for AC power supplies that are surge protected and filtered to remove any radio frequency interference. Further, floor coverings in rooms housing sensitive electronic equipment should be made of anti-static materials.

The **student processing mode** refers to the way students are to be handled in the educational setting. Traditionally the cohort processing mode has prevailed: students are grouped by age or by grade and then processed together as a unit with the duration of processing extending for at least a semester or a school term. Most of our school facilities foster this mode -- and may even guarantee it (by virtue of the egg crate nature of classrooms and learning spaces). The opposite end of this student processing mode continuum is individualization with the student remaining in a setting only long enough to complete the assigned learning objectives. Time does not have to be a contributing factor. To facilitate the individualized processing mode, learning spaces must be flexible and the notion of classroom should be forgotten.

Learning styles impose another constraint on the learning environment. Learning theory tells us that students first learn through concrete experiences and later they learn abstractly. Moreover, there is some evidence suggesting that some students remain at concrete levels and never progress to the point of abstract learning. Years ago most of the students that remained in school past 14 or 15 years of age were able to learn abstractly and the school spaces were designed (at least secondary schools) without significant attention to learning in the concrete mode. With the current expectation that most students should finish high school and perhaps continue beyond, there is a need to think about the needs of students who learn best in the concrete mode. For these students there should be some provision for practical applications of learning. With the changes in the occupational fabric of our nations, there is less and less work that can be seen and observed by students in their daily lives. More and more of the occupations are esoteric and performed beyond the observation of most students. Classrooms might be used to bring the students face to face with aspects of occupations by providing some resources for practical applications of theory -- an industrial arts lab operating in conjunction with academic programs, for example. Alternatively, the educational facilities could be designed to expose opportunities for practical learning -- the physical plant could become a part of the educational experience. Building systems that are open to observation have been used for successful energy conservation and custodial care programs where the physical plant has been the classroom.

Other Constraining Factors

While most of the impacts of buildings on people and the way they perform are included in the perceptual, individual and program constraining factors, some are more difficult to classify and are included in this section.

Safety is an important aspect when one considers the risks of natural and man-made disasters. While the western world has not been torn by terrorism to the same extent as other parts of the world, the potential (though remote) does exist for it to happen anywhere. Transportation systems, power grids, communication lines, water and food supplies are all vulnerable to terrorists. More importantly, there have been a number of instances of accidents that produce life-threatening situations in communities (train derailments, gas line explosions, Three-Mile Island, the chemical spill in Bhopal, India, the Chernobyl disaster, and so forth) and they all serve to remind us that this threat is often not far away. Unpleasant as the prospect is, it may be worthwhile to consider making some public facilities disaster proof -- occupants should be afforded protection and they should derive a strong sense of safety and security from the facilities. The results of natural disasters, industrial accidents, social strife or terrorism in communities could place great demands on schools and other public buildings to provide refuges, shelters and emergency supplies and support systems.

Operation, maintenance and security of the physical plan could be facilitated by technology. "Smart cards" could permit access to the facilities. Robots could perform routine functions (e.g., cleaning) and sensors could be used to signal abnormal plant operations. All of these features have impacts on how the facilities are used and when they are used.

Linkages with other institutions are essential. Educational planning should be regarded as but one component of over-arching societal planning. Out of the over-arching societal plans there should flow many other parallel plans all impacting students and schools and these plans should be integrated. Examples where these plans should link include provisioning of day care, out-of-school care for children, and health services. Linked planning is imperative if educational facilities are to be used, to any significant degree, for purposes other than education either during or after regular school hours.

Summary

In all probability educational facilities are not neutral but rather aid or inhibit learning and human performance -- either they convey subtle messages (perceptual constraining factors), they aid or inhibit performance of the occupants (individual constraining factors), or they influence programs and the way they are offered (program constraining factors). While too little is known about the causal relationships, common sense may be used to avoid building facilities that unduly constrain or inhibit programs or human performance. Further research and careful attention may even identify ways in which facilities can contribute to the enhanced performance of occupants.

References

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Appendix 2

Feasibility Assessments

Next of kin to evaluations are feasibility assessments. While evaluation is defined as the process of ascertaining decision areas of concern, selecting appropriate information, and collecting and analyzing information in order to report summary data that is useful to decision makers in the process of selecting among alternatives, feasibility assessment is a process that focuses on the capability of a program or innovation being carried out or completed successfully and with predicted success significantly greater than chance. Evaluations are carried out during or at the conclusion of programs and initiatives. Feasibility assessments are carried out prior to launching a program or initiative. Feasibility assessments involve examination of a number of facets or feasibility constraints: qualitative (effectiveness and efficiency), organizational, technical, political, pedagogical, economic, timeliness, and generalizability.

Qualitative. The qualitative feasibility of a program or initiative is an expression of (a) the **effectiveness** and (b) the **efficiency** of the program or initiative. Effectiveness is determined by the degree to which stated objectives are achieved. Efficiency describes the degree to which resources are used to produce a unit of output (or to achieve a stated objective. Effectiveness is doing the "right" thing. Efficiency is doing things "right".

Organization. Organizational feasibility describes the impact an innovation or change may have on the organization. Three areas of potential impact include: (a) the need for reorganization in order to implement the change; (b) resistance to the change; and (c) human resources which are inadequate by virtue of quality and/or quantity.

Technical. Technical feasibility describes the availability of (a) the necessary hardware (things) and (b) software (processes) required to implement an innovation.

Political. Assessing political feasibility constitutes determining that an innovation meets the needs of its clientele in a way that does not conflict with social values and norms.

Pedagogical. Pedagogical feasibility describes the extent to which an innovation, or program, is educationally sound.

Economic. The economic constraint is composed of two components. First the program is constrained by its cost-benefit or cost-utility ratio. Secondly, the program is assessed in terms of cost-fit (the extent to which the innovation can be financed from existing resources).

Timeliness. Timeliness assesses feasibility in terms of the relevancy of the approach both now and in the foreseeable future.

Stated another way, a timely innovation should be able to interface with known and foreseeable constraints.

Generalizability. Assessment of generalizability focuses on the number of areas in which an innovation may be applicable.

When it comes to collecting information to serve as the basis for deciding the feasibility of a program or initiative, there are two sources: theoretical information (armchair considerations) and operational information (information collected through consultation, or on the basis of assessments, simulations and demonstrations). Of these, the most reliable sources are those based on operation.

A set of feasibility assessment forms that may be adapted to suit any innovation or initiative follow. Form 1 is intended to serve as a summary of the nine dimensions assessed by Form 2.

Feasibility Assessment Framework: Form 1

Overall Feasibility	**Sub-Score**
1. **Organizational Constraint**: need for reorganization in order to implement the change; resistance to the change; and human resources which are inadequate by virtue of quality and/or quantity	
2. **Timeliness Constraint**: relevancy of the approach both now and in the foreseeable future	
3. **Generalizability Constraint**: number of areas in which the innovation may be applicable	
4. **Pedagogical Constraint**: extent to which the innovation, or program, is educationally sound	
5. **Qualitative (Efficiency Constraint)**: degree to which resources are carefully used to produce a a unit of output or to achieve a stated objective (i.e. more for less)	
6. **Qualitative (Effectiveness Constraint)**: extent to which stated objectives are achieved or achievable	
7. **Technical Constraint**: availability of the necessary hardware (things), software (processes), and human resources (skills and abilities) required to implement the innovation	
8. **Political Constraint**: extent to which the innovation meets the needs of its clientele in a way that does not conflict with social values and norms	
9. **Economic Constraint**: does the innovation yield an acceptable cost-benefit ratio and is it affordable	
Total Score	

Feasibility Assessment Framework: Form 2

1. **Organizational Constraint:** need for reorganization in order to implement the change; resistance to the change; and human resources which are inadequate by virtue of quality and/or quantity.

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
1.1 Provides for choice in how educational objectives are to be achieved	1	2	3	4	5	
1.2 Appropriately involves teachers and others in the various stages of curriculum development, implementation and evaluation	1	2	3	4	5	
1.3 Enables curriculum programs to be phased in gradually as development progresses	1	2	3	4	5	
1.4 Provides distinct advantages for students	1	2	3	4	5	
1.5 Provides distinct advantages for teachers	1	2	3	4	5	
1.6 Serves the self-interests of teachers	1	2	3	4	5	
1.7 Roles and responsibilities of all participants clearly defined	1	2	3	4	5	
Organizational Constraint Sub-Score						

2. Timeliness Constraint: relevancy of the approach both now and in the foreseeable future.

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
2.1 Enables programs to be revised and up-dated constantly without abandoning the entire program and starting over	1	2	3	4	5	
2.2 Increases the likelihood of meeting the changing needs of students	1	2	3	4	5	
2.3 Is compatible with other on-going long-range planning initiatives	1	2	3	4	5	
Timeliness Constraint Sub-Score						

3. Generalizability Constraint: number of areas in which the innovation may be applicable.

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
3.1 Applicable to a variety of subject areas at elementary, secondary and post-secondary levels	1	2	3	4	5	
3.2 Can be applied by a teacher in a conventional classroom	1	2	3	4	5	
3.3 Can be applied in the team approach by a team of teachers, aides and specialists	1	2	3	4	5	
3.4 Could be used in most school applications: public, private, distance education, post-secondary	1	2	3	4	5	
3.5 Is acceptable to teachers	1	2	3	4	5	
3.6 Is acceptable to administrators	1	2	3	4	5	
3.7 Is acceptable to students	1	2	3	4	5	
3.8 May be used by any staff member, experienced or novice	1	2	3	4	5	
3.9 Is generalizable to many different subject areas	1	2	3	4	5	
3.10 Is generalizable to school-wide applications	1	2	3	4	5	
3.11 Is generalizable to system-wide applications	1	2	3	4	5	
3.12 Is generalizable to province-wide applications and initiatives	1	2	3	4	5	
Generalizability Constraint Sub-Score						

4. **Pedagogical Constraint:** extent to which the innovation, or program, is educationally sound.

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
4.1 Enables many different specialists to make contributions to the instructional program	1	2	3	4	5	
4.2 Enables students to see both short-term and long-term objectives	1	2	3	4	5	
4.3 Facilitates evaluations which help students see where they are going and how they are progressing	1	2	3	4	5	
4.4 Facilitates the evaluation of students on the basis of performance	1	2	3	4	5	
4.5 Increases student motivation	1	2	3	4	5	
4.6 Increases the likelihood that objectives to be attained by students match the students' needs	1	2	3	4	5	
4.7 Provides clear insight into those student behaviors which should be evaluated	1	2	3	4	5	
Pedagogical Constraint Sub-Score						

5. **Qualitative (Efficiency Constraint):** degree to which resources are carefully used to produce a unit of output or to achieve a stated objective (i.e., doing things right, more for less).

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
5.1 Enables curricular programs to be developed by most teachers without extensive inservice training	1	2	3	4	5	
5.2 Facilitates evaluation of the instructional program	1	2	3	4	5	
5.3 Makes efficient use of the time spent in planning and preparing instruction	1	2	3	4	5	
5.4 Makes efficient use of personnel such as teachers, aides, and specialists in the instructional program	1	2	3	4	5	
5.5 Pinpoints critical curriculum areas needy of revision on the basis of student performance in the curriculum	1	2	3	4	5	
5.6 Reduces the amount of time spent by teachers in dispensing information and increases the time available for interaction with students	1	2	3	4	5	
5.7 Reduces the time spent in maintaining student records	1	2	3	4	5	
5.8 Reduces the time spent in activities such as storing and retrieving student records, instructional materials and learning resources	1	2	3	4	5	
Efficiency Constraint Sub-Score						

6. Qualitative (Effectiveness Constraint): extent to which stated objectives are achieved (i.e., doing the right things).

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
6.1 Clarifies the purpose of particular curriculum objectives	1	2	3	4	5	
6.2 Encourages the development of clear statements of goals and objectives	1	2	3	4	5	
6.3 Identifies redundancies and gaps within the curriculum	1	2	3	4	5	
6.4 Increases the likelihood that the curriculum will be regarded as a whole rather than as discrete fragments	1	2	3	4	5	
Effectiveness Constraint Sub-Score						

7. Technical Constraint: availability of the necessary hardware (things), software (processes), and human resources (skills and abilities) required to implement the innovation.

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
7.1 Minimizes the need for processes and/or skills beyond the capabilities of teachers	1	2	3	4	5	
7.2 Requires equipment and resources not readily available in most classrooms	1	2	3	4	5	
7.3 Requires equipment and resources not presently available at any price	1	2	3	4	5	
Technical Constraint Sub-Score						

8. Political Constraint: extent to which the innovation meets the needs of its clientele in a way that does not conflict with social values and norms.

	Unsatisfactory	**Below requirements**	**Meets requirements**	**Above requirements**	**Exceptional**	**Score**
8.1 Allows each student to be treated as an individual	1	2	3	4	5	
8.2 Enables students to become autonomous learners	1	2	3	4	5	
8.3 Enables students to progress individually at their own rate	1	2	3	4	5	
8.4 Enables students to pursue independent programs	1	2	3	4	5	
8.5 Fosters professionalization of teachers	1	2	3	4	5	
Political Constraint Sub-Score						

9. **Economic Constraint**: extent to which the innovation yields an acceptable cost-benefit ratio and is affordable.

	Unsatisfactory	Below requirements	Meets requirements	Above requirements	Exceptional	Score
9.1 Yields an acceptable cost-benefit ratio	1	2	3	4	5	
9.2 May be implemented within available budget	1	2	3	4	5	
Economic Constraint Sub-Score						